SEP 26 1941

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PRINTED ON THIN PAPER FOR FOREIGN CIRCULATION.

ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY CHAS. COOPER AND J. FOSTER PETREE.

TEMPORARY OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 18 & 20, COMPTON ROAD, HAYES, MIDDLESEX.

VOL. 152—No. 3947. *LONDON: FRIDAY, SEPTEMBER 5, 1941.* *Registered at the General Post Office as a Newspaper* PRICE 1s. BY FOREIGN POST 1s. 3d.

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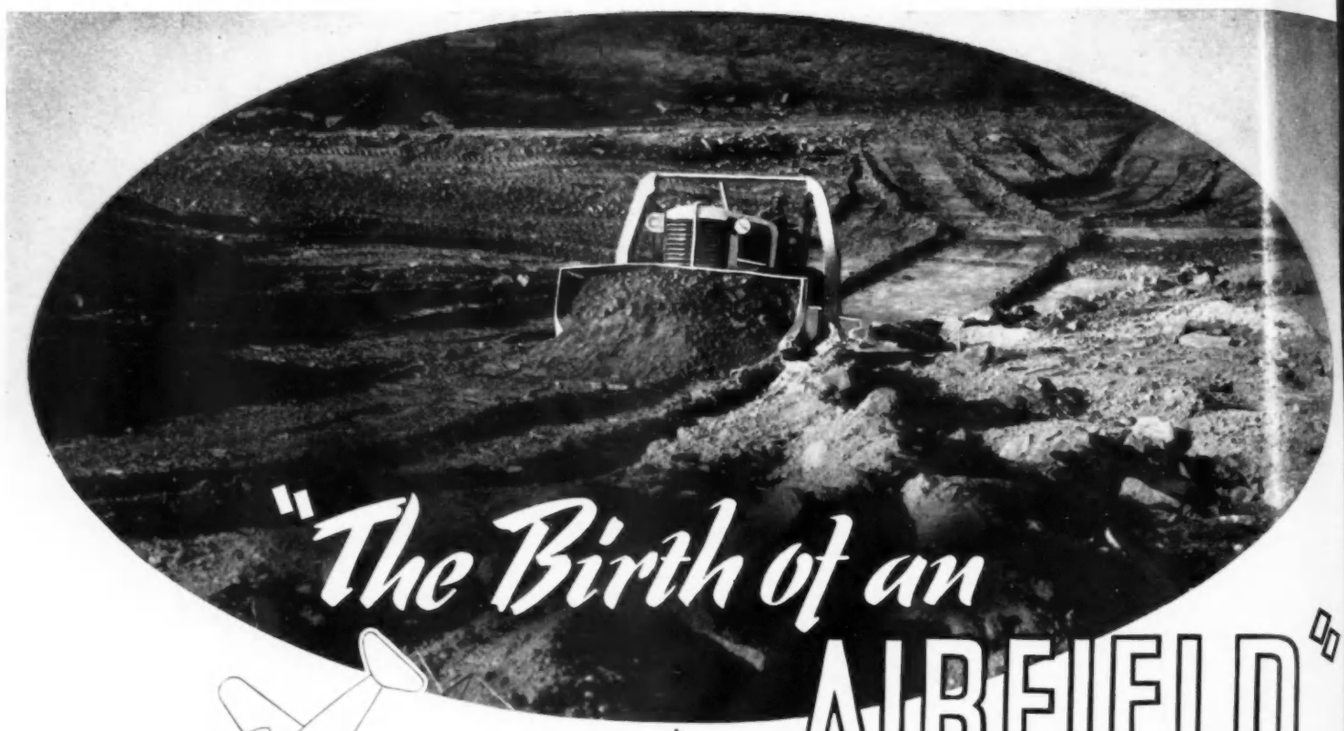

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SAMPLING GAS-BORNE PARTICLES.

(*Concluded from page* 143.)

In the endeavour to fulfil the requirements previously referred to, and with the examination of oil mists in mind, Mr. Stairmand has developed and tested two types of sampling filter embodying some novel and interesting features. The first of these is the simple arrangement shown diagrammatically in Fig. 9. It consists of a cylindrical container with conical ends for the incoming sample of particle-laden gas and the outlet to the extractor, respectively. The filtering medium is Stillite—a proprietary form of de-shotted slag-wool composed of long fine fibres which are much stronger and less friable than those of ordinary slag wool. The fibres are, of course, in random directions, not arranged either along or across the path of the gas. The bulk density of the Stillite as packed into the filter is about 17 lb. per cubic foot, so that the filter shown in Fig. 9 would contain about 2 oz., the cost of which is a negligible fraction of a penny. Mr. Stairmand's experiments have demonstrated

Fig. 9.

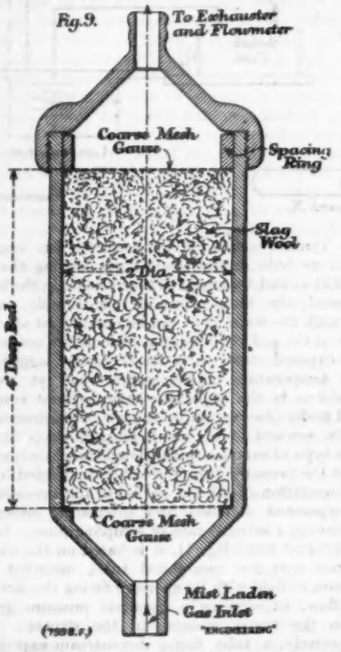
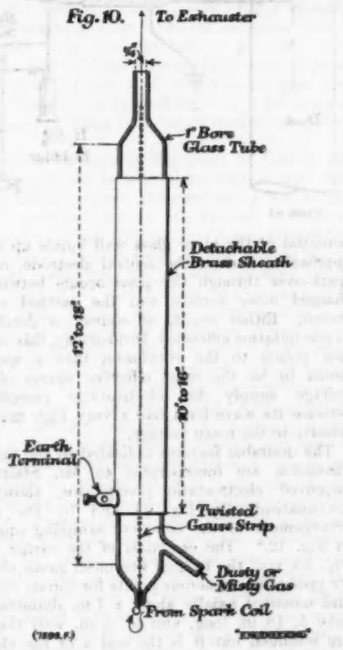


Fig. 10.



that Stillite filters can completely remove the finest oil mist, comprising particles down to less than half a micron in diameter. The material has the further advantage of allowing sampling gas speeds up to about 1 ft. per second to be used without sacrifice of efficiency, as compared with a maximum efficient speed of about 2 in. per second for ordinary slag wool. Thus a filter of the size shown in Fig. 9 will deal with 70 cub. ft. of gas per hour, at which rating the pressure drop through it amounts to about 8 in. water head.

If the Stillite filter is to be used for sampling oil mists, it is packed and afterwards thoroughly rinsed with ether and dried in order to remove all the ether-soluble matter that would otherwise be extracted along with the oil in the subsequent treatment. The inlet end of the filter is connected by clean tubing to a sampling tube, consisting of an open-ended tube mounted in the duct with its open end facing upstream. The outlet is connected, through a suitably sensitive flowmeter, to an ejector, suction pump, fan, or other form of aspirator. With this apparatus a measured volume of the mist-laden gas is drawn through the filter, the oil collected is extracted with ether, the latter evaporated and the residual oil weighed. Hence, from the known volume of the gas sample, the concentration of the oil comprising the mist can be determined. For the sampling of fine powders, the same apparatus is used, and, for certain materials, the weight of the sample of powder can be determined by extraction with ether or alcohol. If the powder reacts with, or is otherwise permanently affected by, such volatile liquids as are useful for extraction, the weight of the sample can be determined by weighing the filter before and after use, though this is not so accurate as direct weighing of the extract alone, since the weight of the filter is very large compared with the probable weight of the sample.

If the extraction process is employed, it is not possible, with certainty, to analyse in respect of particle size the residue after evaporation. The Stillite filter is thus a robust and simple form of filter most suitable for examining mists and powders of which the distribution of particle size is either not required to be determined or can be determined separately by some other method of examination; for example, by an elutriator or sedimentation cell in the case of powders, or by microscopic examination in the case of oil mists.

The extreme fineness of the particles comprising oil mists such as are produced by air compressors, and the demand for highly refined means of determining the efficiency of simple filters of packed cotton-wool or slag-wool, has led Mr. Stairmand to carry out some experiments upon precipitators depending for their action upon the attraction of opposite electrostatic charges. This principle can be applied, of course, to solid as well as to liquid particles, and it is particularly valuable for obtaining samples of particles of sizes small enough to pass most types of mechanical or solid filter. While, for example, the Stillite sampler in Fig. 9 has been found successful for oil mists, a filter of tightly-packed cotton wool is ineffective against oil particles less than 10 microns in diameter. Thus, the chief requirement of the laboratory type of electrostatic precipitator developed by Mr. Stairmand was that it should be, as far as could be ascertained, 100 per cent. efficient in trapping solid or liquid particles less than 10 microns in size.

An early form of his instrument, illustrated in Fig. 10, consists of a 1-in. bore straight glass tube, 12 in. to 18 in. long, supported with its length vertical and having a ¼-in. outlet sealed-on axially at the upper end, and an inlet of equal size sealed as a branch a little way above the lower end. Into the extreme lower end is sealed a platinum wire protruding upwards into a little mercury by means of which good electrical contact is maintained with the central electrode. This consists of a strip of 80-mesh copper gauze, about ¼ in. wide, twisted helically around the axis of the glass tube, its lower end dipping into the mercury, and its upper end terminating just within the outlet tube. The sharp edges of the gauze serve to promote corona discharge, which is essential for efficient precipitation, and also help in rectifying the high-tension electrical supply from a spark coil, though this latter point is of less importance, since the current is already practically uni-directional. The low-voltage electrode is a tubular brass sheath, fitted with a terminal for an earth connection. It may be slid on to the glass tube while the precipitator is in use for sampling and removed to facilitate subsequent examination of the precipitate. Thus, a number of glass collectors can be used successively with one detachable brass sheath and one source of high-tension electricity; or, alternatively, a single source of high tension current will serve several precipitators simultaneously. The glass tube itself serves the dual purpose of making the precipitator easy to clean when the sample is removed, and of allowing an ordinary spark coil to be used for charging the central gauze electrode. The glass prevents spark-over at the peaks of the supply voltage (which may attain 100,000 volts), and encourages a regular and intense corona discharge.*

In use, a sample of mist-laden gas is drawn from some convenient representative position in a duct of the system under consideration. A suction pump or ejector may be used for this purpose, but since the pressure drop through the precipitators is almost negligibly small, the kinetic head of the gas flowing along the duct can often be used for aspirating the sample, by the combination of "facing" and "trailing" tubes exemplified in Fig. 11, page 182. By one or other of these means, mist-laden gas is passed through the precipitator tube until a sample of sufficient weight has been collected, whereupon the sampling connections are removed, the glass branches closed with small stoppers, and the oil which collects on the walls and at the bottom of the tube is extracted with ether and transferred to a weighed vessel. The solvent is evaporated and the residual oil weighed. Owing to the small size of the apparatus and the ease with which it can be thoroughly cleaned, oil samples as small as 1 mg. in weight can, it is claimed, be collected with a high degree of accuracy.

The capacity of the apparatus shown in Fig. 10 is about 1 cub. m. of gas per hour for the 12-in. tube and 2 cub. m. per hour for the 18-in. tube, the corresponding linear velocities being about 2 ft. and 4 ft. per second, respectively. Within this range the efficiency of separation is said to be 100 per cent. for particles down to 1 micron, or a little smaller, in size, but the efficiency is somewhat reduced if higher sampling speeds are used. It is easy to understand that only at sufficiently low speeds of the gas along the precipitator will all the entrained particles come into contact with the glass wall when moving under the electrostatic influence of the discharge from the axial electrode. For this reason, therefore, some means of continuously observing the rate of gas flow, as distinct from an integrating meter, is a desirable adjunct to the precipitator. A small Venturi meter, provided with an appropriately sensitive manometer, is very suitable for this purpose since it introduces little overall resistance to the sampling flow. The meter is preferably arranged in series with a valve to permit adjustment of the rate of flow, and both meter and valve should be inserted on the down-stream side of the precipitator, *i.e.*, between the precipitator and the aspirator, where, being in contact with cleaned gas, they are not liable to become coated or stopped-up with a deposit of oil mist or dust. One other useful function of a valve or cock in the sampling line is that the experimenter can stop and re-start the sampling flow immediately if the corona discharge from the electrode is momentarily interrupted as the result of imperfect performance of the energising induction coil.

A further important point brought out by experiments with electrostatic precipitators is that condensation of moisture within the apparatus tends to prevent its satisfactory operation by lowering the insulation between the high-voltage electrode and the earthed walls, thus reducing the potential

* This phenomenon has been remarked by other investigators.

SAMPLING GAS-BORNE PARTICLES.

Fig. 11.

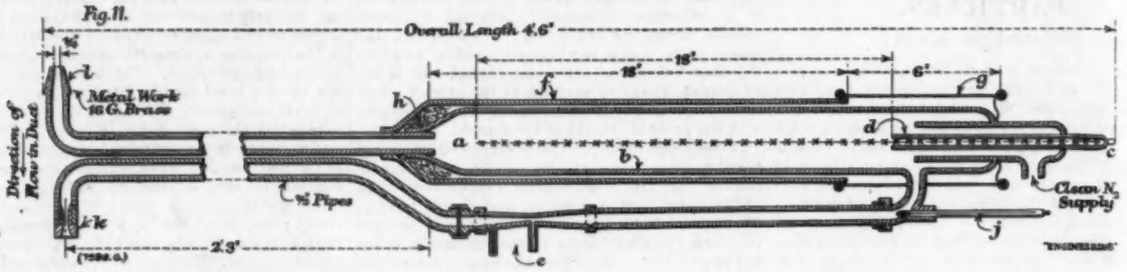
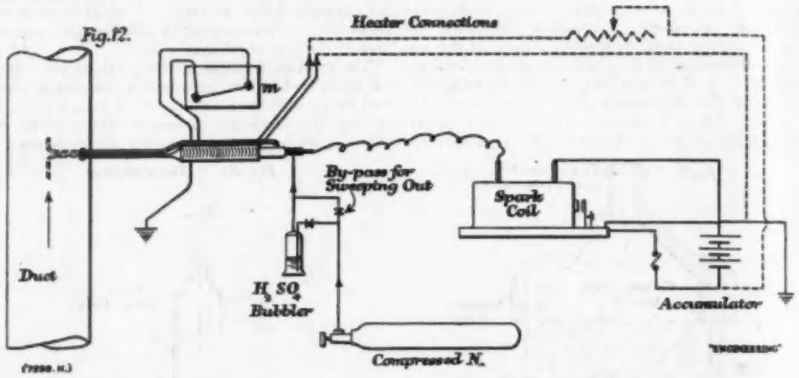


Fig. 12.



difference available for charging the entrained particles. Since the precipitator can only be used conveniently outside the duct which conveys the gas under examination, it tends to remain at the temperature of the ambient air, which will in general be below the dew point of hot or moist gases. Undesirable condensation will, consequently, take place unless the precipitator tube, and preferably the sampling nozzle and connecting pipes also, are heated above that dew point. A convenient method of preventing condensation, therefore, is to surround the tubes with electrical heating coils by which the temperatures of the various parts of the apparatus may be controlled within desired limits.

Apart from condensate, or perhaps under some conditions associated with it, there is often a slight tendency for the insulation to be impaired by deposition of the gas-borne particles upon the high-voltage electrode. It has been found that an auxiliary current of clean dry gas from a separate source, directed along the electrode from the end which is connected to the induction coil, successfully prevents such deposition. Even when the fluid under examination is steam, a small current of dry air supplied near the root of the central electrode will maintain the insulation. The supply of dry gas can be arranged conveniently from a cylinder of compressed carbon dioxide or nitrogen, the main purpose of which is to enable the whole of the apparatus to be swept clean of air before being used to sample an explosive gas.

Although the peak voltages obtainable from a good quality X-ray type spark coil are considerable—of the order of 150,000 volts—they are, nevertheless, limited, and it is reasonable to suppose that the highest efficiency of precipitation will occur when the radial length of the brush discharge from the central electrode is comparable with the radius of the precipitator tube. The insulation difficulties encountered with precipitators of large diameter are also considerable, and really high efficiencies have been unobtainable with them. With glass-lined precipitators of about 1 in. diameter, however, experiments have demonstrated that the glass itself exerts a beneficial effect, to the extent that higher overall efficiencies can be obtained with glass-lined precipitators using a spark-coil electric supply than can be achieved with smoothed direct current, whatever the voltage available. With direct current, indeed, sparking takes place through the glass before the precipitation efficiency approaches that obtained with the markedly peaked form of the spark-coil voltage wave. A tentative explanation of this effect is based on the reasonable assumption that there can be little flow of current through the wall of the glass tube, and that the current dissipation must, therefore, take place over the surface of the glass. When the potential is supplied from an induction coil, the maximum, or peak, voltage occurs only for a small proportion of each cycle and the rate of supply of electrons is limited so that the charge is able to leak away from the inner surface of the glass as fast as it is conveyed thereto. The result is that the inner glass wall remains at a comparatively low potential, and that a steep voltage gradient is maintained between the central electrode and the walls—a condition favourable to high efficiency of precipitation, and to very high peak voltages at the central electrode.

With a smoothed direct current, by contrast, the inner surface of the glass may be supplied with electrons faster than they can leak away. Thus the potential of the inner glass wall builds up until it approaches that of the central electrode, or until spark-over through the glass occurs between the charged inner surface and the earthed exterior sheath. Either event, of course, is detrimental to precipitation efficiency. Incidentally, this explanation points to the conclusion that a spark-coil seems to be the most effective source of high-voltage supply for electrostatic precipitation, because its wave-form has a very high maximum relative to the mean voltage.

The desirable features indicated in the foregoing discussion are incorporated in Mr. Stairmand's improved electrostatic precipitator, shown diagrammatically in Fig. 11 and by the general arrangement of the complete sampling apparatus in Fig. 12.* The essentials of the earlier model, Fig. 10, viz., the twisted fine-mesh gauze electrode *a c* presenting numerous points for corona discharge and mounted axially along a 1-in. diameter glass tube *b*, 18 in. long, and of $\frac{1}{16}$-in. wall thickness, are retained, but it is the end *a* of the electrode remote from the high-voltage supply connection *c* that now first encounters the dust-laden sample of gas. An insulating, tubular support *d* for the electrode is sealed into the end of the precipitator tube and forms the core of an annular passage of $\frac{1}{32}$-in. to $\frac{1}{16}$-in. radial width, along which flows throughout the sampling operation a slow stream of clean nitrogen to inhibit condensation and consequent loss of insulation. By bubbling the nitrogen through sulphuric acid, both its dryness and a controlled slow rate of flow are ensured. If the inlet pressure of the clean nitrogen supply be kept low enough, the inflow of the dust-laden sample will hardly be affected and the nitrogen itself will pass out along with the cleaned gas. Since, however, it passes through the Venturi flow-meter *e* a small correction to the sampling rate may be deemed necessary. The simple, earth-connected, metal sheath of Fig. 10 now incorporates a heating coil of 200 watts capacity and is pulled up by spring clips *g* against an asbestos packing *h* bearing on the inlet end of the precipitator. Similar heaters, of 100 watts and 50 watts capacity, respectively, are wound around the pipe connections between the sampling nozzle and the precipitator, and around the Venturi meter. A thermometer *j* is mounted with its bulb in the cleaned gas leaving the precipitator, and by means of thermostats in the heater circuits, the temperature of the sample passing through the instrument can be maintained above its dew point and condensation of moisture prevented. All exposed metal parts are thermally lagged, and the temperature of the sample gas at various positions in the apparatus may be kept constant and under observation by the use of thermocouples.

On account of the small pressure drop through this type of sampler, with the additional advantage that the pressure drop is sensibly unaffected by the accumulation of filtered particles, the inventor has incorporated a novel and interesting means of achieving a suitable rate of sampling flow. As will be evident from Fig. 11, it is based on the circumstance that an open-ended tube, mounted in a stream of fluid with its aperture facing the direction of flow, experiences a dynamic pressure greater than the static pressure in the stream; while conversely, a tube facing downstream experiences a suction. By connecting the up- and down-facing tubes respectively to the inlet and outlet from the precipitator, a pressure differential is thus available to cause flow through the apparatus. Since, moreover, this pressure and suction are both dependent upon the speed of the stream in which the facing and trailing tubes are immersed, the overall differential can be adjusted so that the rate of sampling flow is automatically kept at a constant proportion of the rate of flow in the duct. In the arrangement described by Mr. Stairmand, the automatic velocity balancing is such that, at the particular sampling rate for which the precipitator is designed, the differential between the facing and trailing tubes just balances the pressure drop through the whole of the apparatus. If the duct velocity exceeds or is less than this design figure, the compensation for pressure drop through the apparatus will not remain exact because the differential is proportional to the square of the duct velocity, whereas the aerodynamic resistance to flow through the tubes in the apparatus is more nearly proportional to the first power of the velocity at the nozzle. The pressure drop through the tubes is liable to be affected by dust deposits and cannot be exactly predicted. For this reason, therefore, and also to ensure that the bulk of the resistance is proportional to the square of the velocity, it is recommended that the apparatus be designed so

* The special parts of the improved apparatus have been tested separately, but the apparatus has not yet been given a large-scale test, owing to pressure of other work.

that the differential head due to the facing and trailing tubes considerably exceeds the resistance through the apparatus. The excess pressure can be absorbed by fitting a constriction *k* in the end of the trailing tube.

For the arrangement illustrated in Fig. 11 it is stated that the resistance in the connecting pipes is only some 10 per cent. of the total, so that adequate compensation can be made effective over a wide range of velocities, which range can be extended by changing the constriction in the trailing tube. Over small ranges of velocity, the deviation from automatic balance has been shown experimentally to be less than 10 per cent. of the duct velocity; and the apparatus to the dimensions given in the figure will give a balance sufficiently correct for most purposes. It may be noted that the nozzle in the facing tube, which entrains the gas to be sampled, is of ¼-in. internal diameter diverging to ½-in. at its junction with the inlet pipe to the precipitator. The nozzle is readily detachable for cleaning.

The Venturi meter *e* for measurement of the sampling rate, whence weight concentration of dust or oil-mist can be deduced, is incorporated along with the precipitator tube and arranged in the outlet pipe at the end of a straight length of more than 10 pipe diameters, which ensures reasonably steady conditions of transverse flow distribution. A sensitive manometer connected to the Venturi is indicated at *m* in Fig. 12. This diagram also shows a suitable arrangement of electrical supply and connections to the spark-coil and heating coils. An X-ray type 3-in. or 4-in. spark coil is said to provide adequate potential to operate one or more samplers of the dimensions shown in Fig. 11. The apparatus, including all auxiliaries, is estimated to weigh about 20 lb., and can thus be regarded as readily portable and capable of being manipulated by one operator. In this connection it may be noted that the precipitation chamber or tube is detachable from the rest of the apparatus, so that it can easily be cleaned and the collected sample washed out for weighing. Alternatively, if more convenient, the sample may be weighed in the precipitator and its net weight obtained by difference. It may be remarked, also, that the design does not include either a stop-cock in the sampling line or a flap over the nozzle in the facing tube to prevent the ingress of dust while the nozzle is being inserted into the duct and fixed in position prior to the start of the actual test. In many respects these would be valuable additions, but experience with the earlier model showed them to have certain disadvantages; the recommended procedure is to insert the nozzle into the duct with the axis of the facing and trailing tubes at right angles to the gas flow. In this disposition an equal suction is produced at each, and no flow takes place through the apparatus. When all is in readiness, the apparatus, including the components in the duct, is quickly turned through a right angle so that the facing tube points upstream. Flow will then begin at the correct rate.

WATERWORKS CONVENTION AT TORONTO.—We are informed that the 61st annual convention of the American Waterworks Association, held at Toronto, Canada, from June 22 to 26, was a highly successful meeting. The number of registrations totalled 1,445, compared with a record attendance of 1,467 at the meeting at Kansas City in 1940. Many of the papers presented at the Toronto meeting dealt with matters relating to the functioning of waterworks under war conditions or as essential units in the arrangements for defence.

VILLAGE ELECTRIFICATION IN SWEDEN.—The electrification of rural districts has been actively pursued in Sweden for some years. According to a computation made by the State Fuel Commission last autumn, however, there remained 267,000 households in the country still unprovided with a supply of electricity. Recent statistics show that this number has now been reduced to 210,000, signifying that electricity has been provided for some 60,000 households in less than twelve months. Many of the islands off the coasts of Sweden which, hitherto, have been without current are being gradually connected up with the mainland. Latterly, however, there has been a slowing down of the rural electrification programme on account of present difficulties in obtaining the necessary materials.

DISTRICT HEATING IN THE UNITED STATES AND RUSSIA.

By DAVID BROWNLIE.

FROM the technical and scientific point of view, one of the most serious defects of modern civilisation lies in the fact that the condensing steam engine and turbine still loses some 55 per cent. of the total heat in the coal, or other fuel, in the condenser. Even more serious is the use of the non-condensing engine, of which a particularly bad example is the steam locomotive, operating at a thermal efficiency of no more than 6 per cent. to 8 per cent. Experience with thousands of plants, mostly relatively small, has shown that great economy in fuel can be obtained by employing back-pressure or pass-out engines and turbines and utilising the exhaust steam for heating and process work. The actual thermal efficiency under average conditions is thus raised to, say, 65 per cent. to 75 per cent. by the reduction or elimination of the loss of latent heat.

The exhaust steam can be used directly in individual establishments or by what is popularly termed "district heating." Like most other popular terms concerned with technical subjects, this is inaccurate and indeterminate; however, very roughly, district heating means the supply of steam or hot water by means of long-distance pipe lines for the heating and general services of all types of buildings, extending to a whole district or area of a town.

The worst example of the waste of fuel, in this connection, is the electric power station with condensing steam turbines. Approximately 200,000,000 tons of coal per annum are burned throughout the world in power stations, and some 110,000,000 tons of it are thrown away in the cooling water. In many instances, the amount of heat to be wasted is so great that a main problem is to find a river large enough for the purpose, and it is necessary to descend to the minor absurdity of using cooling towers. In fact, some unfortunate small rivers have to be by-passed almost bodily on their way to the sea through the condensers of successive power stations. The ideal solution, though it seems to arouse the animosity of a surprising number of engineers, is to build and operate power stations with super-pressure and high superheat boilers in conjunction with back-pressure and also pass-out turbines supplying exhaust steam at different pressures to an inner ring of industrial and other premises, and to a much larger outer ring of the shops, houses, and other buildings constituting the average town. In this way the net thermal efficiency of power generation might easily be raised to 65 per cent. or even 75 per cent., instead of the present average of about 20 per cent.

District heating by means of steam (or steam-heated water) has made fairly rapid progress in some parts of the world, especially during the past 15 years. The two chief countries, in a class by themselves, are the United States and Russia. Other countries, prominent in this connection, include Canada, Czechoslovakia, Denmark, France, Germany, and Switzerland. Great Britain, although one of the most suitable countries for the purpose, is completely outclassed, having but a few installations, and these of very small size; which is (or should be) surprising in view of the fact that Britain, on the whole, is an efficient country in its use of small and medium-size industrial back-pressure or pass-out engines and turbines. So far as can be ascertained, moreover, Britain actually originated district heating. As long ago as 1653, Sir Hugh Plat, of London, heated glasshouses with steam from a cast-iron pot placed outside, as described in his book on horticulture, *The Garden of Eden*. James Watt is believed to have used, in 1784, the first elementary steam radiator. It was fitted in his study and consisted of an iron box with connecting pipes through which steam was passed from boilers. In 1825, Matthew Murray, of Leeds, the famous competitor of James Watt, heated his house, which was locally known as "Steam Hall," by means of exhaust steam from the engine of his adjoining works. Meanwhile, in 1804, Oliver Evans in the United States had mentioned in one of his patents the use of exhaust steam from engines for heating.

The reorganisation and improvement of the whole fuel system of Great Britain is long overdue, and one of the most important requirements is an extensive development of district heating. To indicate the possibilities in this direction, I propose to deal in the present article with the two chief countries in which district heating is employed, namely, the United States and Russia, and particularly—as showing what could be accomplished in London and other large cities—with the cases of New York, Detroit, and Moscow. An important point, the significance of which has not yet been generally realised, is that most of the district heating in the United States, and all other countries except Russia, is carried out on thermally inefficient lines by live steam, and not by exhaust steam, so that the total power generated in the heating stations is extremely small. Russia is the only country that has developed district heating upon an extensive scale by using exhaust steam from public-supply electric power stations.

In the United States there are at the present time about 175 district heating companies in operation, probably supplying over 35,000,000,000 lb. of steam per annum, involving the combustion of 2,200,000 tons of coal. Although this is a large figure, it represents only a small proportion of the total heat used in the domestic field, which requires over 100,000,000 tons of coal (anthracite and bituminous) per annum in addition to large amounts of oil, natural gas, coke, and other fuels. The first building in the United States to be heated by steam was the Eastern Hotel, Causeway-street, Boston, in 1844; but this hardly seems to have been a success, as when the steam was turned on all the guests had to depart hurriedly—presumably because of leaks. District heating was made a commercial success in 1877, at his house in Chestnut-avenue, Lockport, New York, by Birdsill Holly, who founded the first steam heating company, known as the Holly Steam Combination.

The largest district heating system in the United States at present is that of the New York Steam Corporation, formed in 1881 by Wallace C. Andrews, a well-known business man of the period, who had investigated the work of Birdsill Holly. In 1882, with Charles E. Emery as chief engineer of the company, the first heating station was put into service at Cortlandt-street, in the Broadway area, supplying steam at 80 lb. pressure through 3 miles of mains. The amount of steam sold to customers in each year since 1922 was as shown in the accompanying Table I.

TABLE I.—*Output of New York Steam Corporation.*

Year.	Steam.	Year.	Steam.
	Lb.		Lb.
1922 ..	3,065,521,000	1932 ..	11,146,438,000
1923 ..	3,660,885,000	1933 ..	11,434,438,000
1924 ..	3,951,885,000	1934 ..	11,450,771,000
1925 ..	4,443,662,000	1935 ..	11,247,118,000
1926 ..	5,560,320,000	1936 ..	11,443,465,000
1927 ..	6,304,475,000	1937 ..	10,393,286,000
1928 ..	7,504,326,000	1938 ..	9,957,719,000
1929 ..	8,590,802,000	1939 ..	10,417,599,000
1930 ..	9,984,873,000	1940 ..	11,282,813,000
1931 ..	10,146,438,000		

The length of steam mains and service pipes maintained by the New York Steam Corporation, expressed as the equivalent length in feet of 12-in. diameter pipe (the actual sizes ranging from 2 in. to 24 in.), from the year 1921 is shown in Table II, page 184. The figures for the length of service mains are not available for the years 1938–40 inclusive, but no considerable change has taken place during that period, and it will be noticed that this applies since about 1932. The present total length is equivalent to approximately 90 miles of 12-in. pipe.

The total cubic feet of space heated in the buildings served by the New York Steam Corporation is given in Table III, page 184, these being approximate figures taken from curves, except for the years 1938–40, for which the exact totals are available.

The New York Steam Corporation has five heat-

ing stations, all operated on modern steam-driven power-station lines, the largest being the Kips Bay plant at 35th-street, on the East River. This station, illustrated in Fig. 1, on this page was erected on the site of a mansion belonging to Jacobus Kip, Clerk of the Common Council of New Amsterdam, built in 1742 and pulled down in 1852. The first section had three very large water-tube boilers, each of 325,000 lb. per hour normal evaporation. In 1927 a fourth boiler, of 375,000 lb. per hour, was added. Steam pressure is normally 285 lb. per square inch, with no superheat, the steam being supplied at the desired pressures, within the range of 100 lb. to 150 lb. per square inch, through reducing valves. Firing is on the bin-and-feeder pulverised-coal system. In 1930, a fifth boiler, of 700,000 lb. per hour normal evaporation, was added, bringing the station up to a capacity of 2,400,000 lb. of saturated steam per hour. This boiler also operates at 285 lb. per square inch.

TABLE II.—*Steam Mains of New York Steam Corporation.*

Year.	Length in Feet of 12-in. Pipe.	Year.	Length in Feet of 12-in. Pipe.
1921 ..	83,989	1930 ..	349,046
1922 ..	87,222	1931 ..	429,825
1923 ..	93,983	1932 ..	471,352
1924 ..	128,298	1933 ..	477,295
1925 ..	138,152	1934 ..	478,100
1926 ..	187,283	1935 ..	477,773
1927 ..	232,976	1936 ..	478,234
1928 ..	253,396	1937 ..	479,942
1929 ..	298,808		

TABLE III.—*Space Heated by New York Steam Corporation.*

Year.	Space Heated.	Year.	Space Heated.
	Cub. Ft.		Cub. Ft.
1922 ..	400,000,000	1932 ..	2,130,000,000
1923 ..	425,000,000	1933 ..	2,120,000,000
1924 ..	520,000,000	1934 ..	2,100,000,000
1925 ..	640,000,000	1935 ..	2,080,000,000
1926 ..	900,000,000	1936 ..	2,090,000,000
1927 ..	1,050,000,000	1937 ..	2,090,000,000
1928 ..	1,210,000,000	1938 ..	2,101,041,000
1929 ..	1,580,000,000	1939 ..	2,104,116,000
1930 ..	1,790,000,000	1940 ..	2,124,709,000
1931 ..	1,920,000,000		

The pulverised-fuel equipment for the five boilers at Kips Bay consists of seven mills in an adjoining building, with a total duty of 160 tons of bituminous coal per hour. Since the New York Steam Corporation system operates under conditions such that little condensate is returned, largely because of the high capital cost that would be incurred by extra pipe lines, and troubles with corrosion, about 90 per cent. of make-up feed is used for the boilers. An important feature of the equipment, therefore, is the softening plant dealing with New York town water.

The 90 miles of mains interconnecting the five stations are of lap-welded steel with welded flanges and corrugated copper expansion joints, and numerous draining stations, capable of operating if necessary at 250 lb. per square inch pressure. Most of the insulation is 85 per cent. magnesia, in blocks 2 in. thick, with canvas and tarred-felt outer covering. The mains are generally laid below the pavements in concrete and tile conduits, with cast-iron covers, the space between the mains and the walls and floor of the conduit being filled with loose slag wool. The mains are threaded in a remarkable fashion among a conglomeration of water pipes, electricity supply cables, and telephone and telegraph cables, and pass underneath tramway lines and over subways and other underground passages.

The annual reports of the New York Steam Corporation after and including the year 1938 do not give as much technical information as previous reports. However, it was stated in 1937 that the heating stations of the Corporation supplied 93 per cent. of the steam they sold, the rest having been purchased from the Consolidated Edison Company. The efficiency (presumably gross) of all the boilers in the heating stations averaged 82·3 per cent. during 1937, as compared with 82·8 per cent. in the previous year. The great progress that has been made during the past nine years is indicated by the fact that, in 1928, the average boiler efficiency of the five stations was 77·4 per cent. (again, presumably gross). It may be stated, also, that in 1940 the New York Edison Steam Corporation, which is now a subsidiary of the Consolidated Edison Company of New York, Incorporated, has a capital stock of 22,833,080 dols., and 3½ per cent., first mortgage bonds of 27,982,000 dols., while loans from associated companies amounted to 6,600,000 dols. The total value of the plant and equipment was 56,174,015 dols., and various other items brought the total assets up to 62,705,933 dols. The actual operating revenue in 1940 was 10,850,747 dols., while the operating expenses were 5,893,266 dols. Maintenance increased the total operating deduction to 9,146,192 dols., leaving a gross operating revenue of 1,704,555 dols. From this various deductions have to be made, particularly interest on loans, leaving a net income for the year of 503,873 dols. I have to express my thanks to the New York Steam Corporation for their courtesy in supplying detailed information for the purpose of this article, including a copy of their valuable and interesting book, published in 1932, entitled *50 Years of New York Steam Service.*

KIPS BAY POWER STATION, NEW YORK.

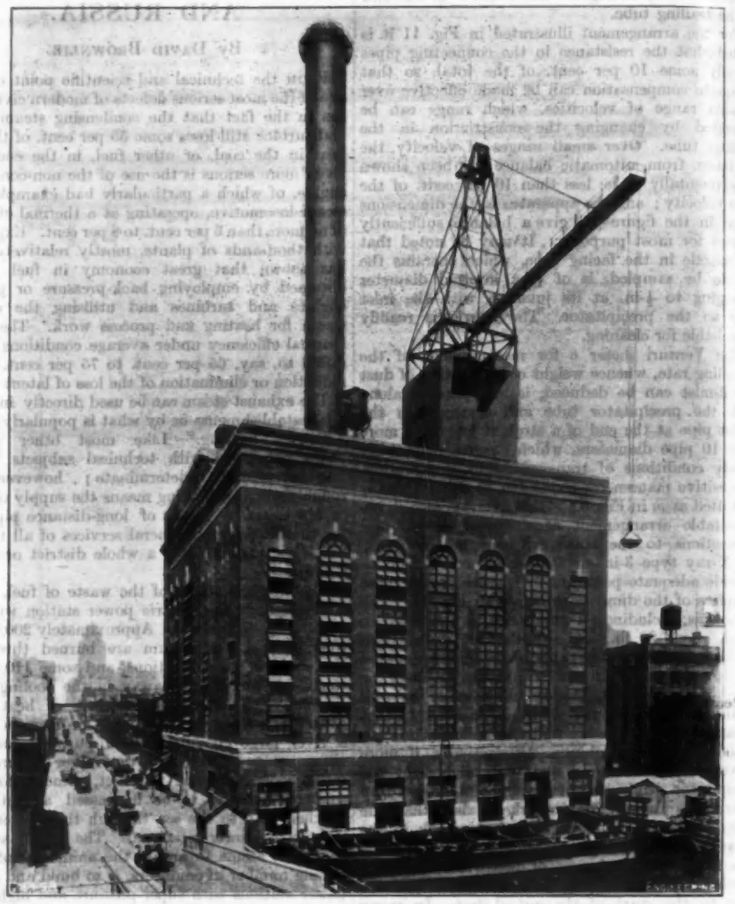


FIG. 1.

The district heating system of Detroit is owned by the Detroit Edison Company, which has at the present time about 1,500 customers and sells approximately 2,250,000,000 lb. of steam per annum through about 25 miles of mains, nearly the whole supply being live steam at 10 lb. to 120 lb. per square inch. It is well known that the Detroit Edison Company is one of the largest suppliers of electricity in the world. The company was formed in 1903 to take over several small stations from the old Edison Illuminating Company, of Detroit. One of these stations, Willis Avenue, operated by slow-speed steam engines driving direct-current generators, instead of being scrapped when the Company built their first large station, was converted into a district-heating station. The reason was that the station was then in a high-class residential area taking direct current, and it proved to be a better commercial proposition at the time to continue to use this plant instead of taking alternating current from the large station and installing transformers, especially as exhaust steam could be sold to surrounding houses and other buildings. For this purpose a separate company, known as the Central Heating Company, was formed, and on the most scientific lines supplied exhaust steam from the engines at high overall thermal efficiency.

Business in the latter connection commenced on December 10, 1903, with 3,000 ft. of mains and 12 customers, and in 1904 another 9,865 ft. were added, followed by further extensions from time to time. In 1916, the Willis Avenue station was completely reorganised, the engines being scrapped and operation carried out on the much less thermally efficient principle of supplying live steam in greatly increased quantity from water-tube boilers; two small back-pressure turbo-alternators, of 500 kW and 1,000 kW capacity, respectively, were installed, to provide the necessary auxiliary power. Meanwhile, in 1904, the Central Heating Company had extended its activities and built a live-steam heating station at Farmer-street, in the business area of Detroit. This station operated until 1926, when it was closed down and the steam supplied from other stations. In 1912, the Central Heating Company built another

WATER-HEATING INSTALLATION AT DETROIT.

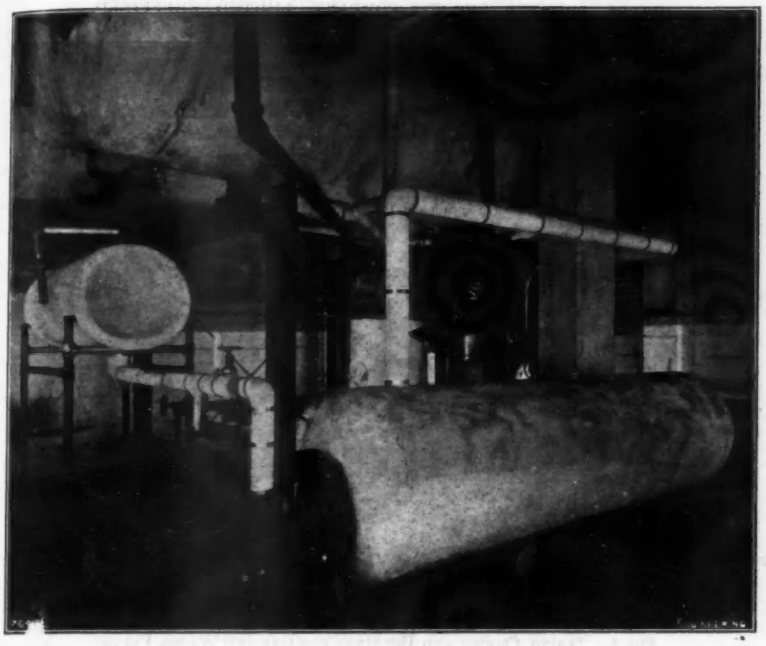


FIG. 2.

live-steam heating station at Park-place; this was closed down in 1927 and, as before, the steam was supplied from other stations. Next, in 1914, the Detroit Edison Company took over the business of the Murphy Power Company, who, since 1904, had been supplying the southern area of the city with exhaust steam from turbo-alternator sets; but in 1915 this station was scrapped. Following upon this, the Detroit Edison Company absorbed the Central Heating Company in July, 1915, and in 1917 built a new live-steam heating station, at the junction of Congress-street and Cass-street, which was subsequently extended.

Because of the increasing demand, there was started up in 1926 the first section of one of the most important steam-heating stations in the United States, namely, Beacon-street, having two very large water-tube boilers. In 1927, a third boiler was added, followed in 1929 by a fourth. Three of these boilers have a heating surface of 41,550 sq. ft. each, and one has 42,370 sq. ft., each having a normal evaporative capacity of about 400,000 lb. per hour; 160 lb. per square inch is the maximum steam pressure, although the usual figure is 125 lb. to 150 lb. A 2,400-kW and a 3,000-kW back-pressure turbo-alternator set are operated, which exhaust partly to the feed heaters and partly to the district-heating mains. On similar lines to the Kipe Bay station, New York, most of the condensed water is not returned because of the high capital cost of the piping that would be required; consequently, the boiler-feed make-up is about 90 per cent. of the total evaporation. A view of some of the high-pressure mains from the Beacon-street plant is given in Fig. 3, page 190, and shows the method of supporting the pipes in the brick-lined tunnel. In 1928, the Detroit Edison Company purchased the relatively small self-contained live-steam heating plant of the General Motor Corporation skyscraper building in Castle Boulevard, which was extended and became the Boulevard heating station. For 1937, the accompanying Table IV gives the essential figures for all the four stations (Willis-avenue, Congress-street, Beacon-street, and Boulevard) added together.

The Detroit Edison Company have furnished detailed figures for several years since 1936 for the total steam distribution losses, that is, the difference between the steam delivered to the system from the boiler plant and the steam metered as condensate by the customer. Figures for some typical years are given in Table V.

In 1940, the amount of coal burnt was 161,500 short tons (2,000 lb.), so that the performance was

TABLE IV.—*Operating Data, Stations of Detroit Edison Company, 1937.*

Steam output (lb.)	2,754,302,000
Coal burnt (short tons)	152,022
Steam output (lb. steam per lb. coal)	9·0
Heating value of coal (B.Th.U. per lb. gross)	13,220
Ash in dry coal (per cent.)	7·4
Steam generation efficiency (gross, per cent.)	80·4
Max. load per hour (lb. per ½-hour periods)	1,139,000

7·2 lb. of steam delivered to the mains per pound of coal. Steam losses in the mains consist of condensation drainage, leakage of steam and condensed water, and errors in metering, the meter

TABLE V.—*Steam Output and Lose: Detroit Edison Company.*

Year.	Steam Output.	Steam Condensate Metered by Customers.	Loss.
	Lb.	Lb.	Per Cent.
1926 ..	2,811,882,000	2,363,189,000	16·00
1929 ..	3,346,479,000	2,890,241,000	13·60
1933 ..	2,468,850,000	2,009,068,000	18·60
1936 ..	2,778,532,000	2,338,715,000	15·80
1937 ..	2,154,302,000	2,262,439,000	17·80
1940 ..	2,903,444,000	2,461,151,000	15·23

readings tending to be low. The system covers an area in the city of Detroit about 3½ miles long, with a width varying from one block of buildings to a mile, including the central shopping, business and financial districts; buildings valued at about 100,000,000 dols. (20,000,000*l.*) are being steam heated.

The insulating covering used before 1909 consisted of asbestos paper, an enclosed concentric air space formed by sheet metal casing, and thick blocks or shaped pieces of wood with tarred canvas on the outside, resting in trenches on crushed stone. This, however, was not very satisfactory because the wood blocks rotted and, after 1909, concrete conduits were used with the pipe line carried on small cast-iron rollers. For the insulation, laminated asbestos composition is now the standard practice, with outer layers of bitumen-impregnated roofing felt strengthened by copper wire. There are two miles of tunnel, with the sides and an arched roof of brickwork, and a concrete floor, and about 6 ft. in maximum height inside, situated 25 ft. to 60 ft. below the street level. For the steam pipe lines in the tunnels, the insulation used is 85 per cent. magnesia and canvas. Expansion joints are of the sliding brass-sleeve type, fixed about every 250 ft., replacing the original diaphragm expansion joints largely used. The standard method of laying a 12-in. main is illustrated in Fig. 4, on page 190.

Steam is supplied at a number of different pressures, from 10 lb. to 120 lb. per square inch, mainly through reducing valves, according to the demands of the customers, who have a total of about 6,800,000 sq. ft. of radiator surface. Fig. 2, on this page, and Fig. 5, on page 190, are two typical views on consumers' premises. Fig. 5 shows the arrangement of the control valves at the point of entry to the building. The insulated steam supply pipe is seen on the back wall, forming a double upward bend, with the company's service valve in the middle. The next fitting is the consumer's operating valve, next to which is a reducing valve controlling the flow of steam to the lagged pipes serving different parts of the building, each having its own separate regulating valve. The smaller lagged pipe leading off to the left of the group of valves is the line supplying a steam water-heater. A water-heating installation is illustrated in Fig. 2. The upper of the two large horizontal cylinders is a water heater for domestic purposes, and the lower is a water-heating economiser, which is connected to the condensate receiver, seen below the left-hand end of the domestic-water heater. A condensate meter is situated below the condensate receiver.

Financially, conditions have been somewhat difficult, largely because of the trade slump of 1929–1933; for example, the year 1937 does not show as good results as 1928, which was about the peak period. Table VI, herewith, shows a comparison between the two years for some of the more important points.

TABLE VI.—*Comparative Returns for 1928 and 1937: Detroit Edison Company.*

—	1928.	1937.
Steam delivered to the system (lb.)	3,007,261,000	2,754,302,000
Steam sold (lb.)	2,503,249,000	2,262,439,000
Coal burned (short tons) ..	168,008	152,992
Net kWh generated (less house consumption)	7,807,400	10,439,900
Number of customers	2,020	1,515
Earnings per 1,000 lb. steam sold (dols.)	1·01	0·84

Because of these and other difficulties, the Detroit Edison Company have not yet been able to adopt the scientific principle, which they intend to follow, of generating steam under super-pressure conditions, such as 1,500 lb. to 2,000 lb. per square inch and operating back-pressure turbo-alternator sets, supplying exhaust steam at 10 lb. to 120 lb. per square inch instead of live steam. Acknowledgments are due to Mr. J. H. Walker, superintendent of central heating and engineer-assistant to the general manager of the Detroit Edison Company, for his courtesy in supplying information and photographs.

(To be continued.)

NICKEL-MANGANESE STEEL IN TRACK WORK.—An installation of double-diamond crossings was made in 1938 at the intersection of the Canadian Pacific and the Canadian National Railways, at Cornwall, Quebec. An austenitic 13 per cent. manganese steel, containing 3 per cent. of nickel, was used for the crossings. It is reported in *The Nickel Bulletin* that an inspection made in July, 1940, showed that the general condition of the crossing was very good, in spite of the fact that it is considered to carry heavier traffic than any other crossing in Canada. The most noticeable feature was the absence of "roll-over" of the metal on the rail heads.

AUTOMATIC CAMSHAFT-HARDENING MACHINE.

THE principles of the Shorter process for the surface-hardening of iron and steel parts are now well known, and it is therefore only necessary to recall briefly that the process consists in the local heating of the surface to be hardened by means of special types of burner using oxy-acetylene or similar fuel gas, followed by immediate water quenching. A number of automatic and semi-automatic machines for dealing with large quantities of parts have been developed in recent years by Messrs. Shorter Process Company, Limited, Celtic Works, Savile-street East, Sheffield, 4, and among the latest of these is that known as the Shorter Type W.1 camshaft-hardening machine. It is stated to be capable of hardening the lobes of from 30 to 50 cast-iron or steel shafts per hour, and, as the heating and quenching operations are under automatic control, uniformity of treatment is ensured. Except for the loading and unloading of the work piece, the operation of the machine is entirely automatic. By push-button control the operator commences the heating and cooling cycles, the periods being predetermined by timing mechanism forming an integral part of the equipment. The machine, which uses oxy-coal gas as the heating medium, is shown in Figs. 1 to 3, on this and the opposite pages. Fig. 1 is a general view of the machine taken from the rear, and Fig. 2 shows a camshaft mounted in position, between centres, with the "gates" carrying the burners open; Fig. 3 shows the gates closed with the burners over the camshaft ready for operation. The main structure of the machine, which is 5 ft. 6 in. in length, 5 ft. in height and 4 ft. 6 in. in width, is built up of mild-steel plates and angle iron bolted together into a box-like structure. Inspection doors are provided where necessary and the watertight base incorporates a well tank.

Upon the main structure is mounted the bed of the machine carrying head and tail stocks, and, to facilitate rapid loading and unloading, the tail stock is fitted with the lever-operated, spring-loaded centre seen in Figs. 2 and 3. The maximum length of camshaft which can be accommodated in the machine is 36 in. The cam lobes are secured in the correct position in relation to the burners by means of a spring-loaded plunger, on the end of which a slot is machined. At one end of the camshaft is cast a small key which engages with the plunger slot and locks the camshaft in the desired position. The two gates are hinged at each end on water-sealed ball bearings and are counter-balanced by adjustable weights. The gates are closed simultaneously by means of spur gears mounted on one end of the spindle carrying them, and they are held firmly in position by spring-loaded plungers. Upon each of the two gates is mounted a removable machined carrier to which are fitted the requisite number of burner brackets. These brackets are, of course, adjustable and are set up in accordance with the contour of each individual batch of camshafts. The fact that the burner carriers are removable avoids delay when a new set-up is necessary as the whole carrier, with its associated burner equipment, may be removed and replaced by another, prepared beforehand on a spare pair of gates supplied for the purpose.

Two of the firm's heavy-duty standard blowpipes fitted with gas distributors or mixing chambers are provided, one for each gate. From the blowpipes copper tubes or flexible leads take the gas to "V"-type burners arranged over the lobes of the camshaft. Furthermore, each burner is connected to a main water feed pipe, suitably arranged on the burner carrier gates, and leading from an automatic water valve housed within the machine behind the inspection door seen on the right in Fig. 1. Each "V" burner is fitted with interchangeable jets for rapid replacement. A high-duty two-stage regulator for the oxygen is fitted on the machine, together with an electrical heating coil. An air-blast valve is also provided to enable the operator to blow out accumulated moisture or water from the blowpipe mixing chamber or gas jets between each operation. This valve is intended to be connected to the client's high-pressure air line.

The automatic timing mechanism may now be described. The machine is fitted with two of the firm's duplex oxy-fuel gas valves placed at the rear of the machine in a sheet-metal box, as seen in Fig. 1. These valves, which work in tandem and are cam-operated, are connected to an Igranic alternating-current solenoid. This operates, through contacts, from one of the timing clocks seen in Fig. 1, by which the heating period can be pre-determined and controlled. Similarly, the main water valve in the machine is connected to a second alternating-current solenoid and is operated, through contacts, from the other timing clock, so that the quenching period after the heating may, in turn, be controlled. When commencing operations, the starting button is pressed and this energises the gas-valve timing mechanism. As a result, a pair of contacts operating the gas-valve relay is closed, thus opening the gas valves. When a pre-determined number of seconds has elapsed the contacts open and shut off the gas. The gas-valve timing mechanism resets itself, and, simultaneously, the solenoid in the water-valve timing mechanism is energised, thereby closing the water-valve contacts, and turning on the water. When the pre-determined quenching period has elapsed, these contacts are opened, thus closing the water valve. We are informed that the control equipment and solenoids can be supplied for any normal alternating-current supply, but that the clocks are only suitable for use with the standard 200-250 volt, single-phase, 50-cycles lighting supply. A safety device is provided in the form of a plunger-operated switch working in conjunction with the gates. This obviates any chance of the operator accidentally starting up the machine while loading is in progress. A rigid removable sheet-metal splash guard, fitted with handles, is provided to cover up the blowpipe and burner assemblies. To protect the underlying metal the interior of the machine is given several coats of red-oxide paint, while the exterior is finished with grey paint.

CAMSHAFT-HARDENING MACHINE.

MESSRS. SHORTER PROCESS COMPANY, LIMITED, SHEFFIELD.

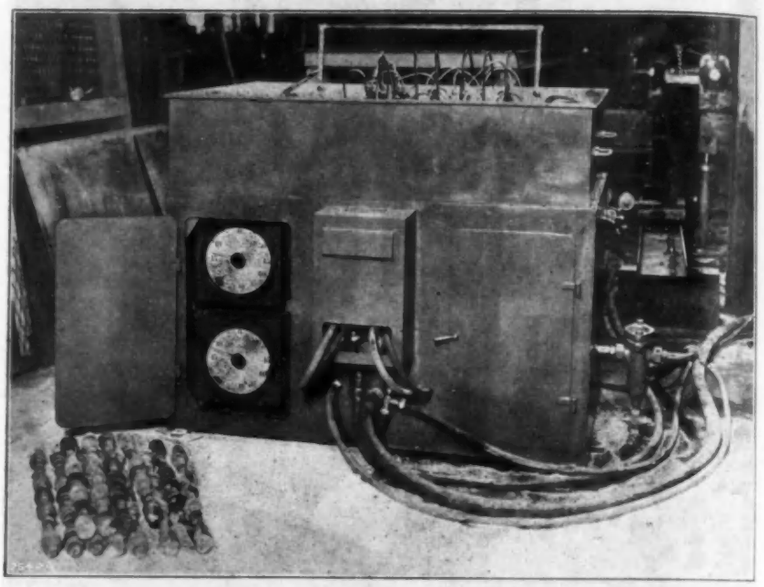


FIG. 1. TIMING CLOCKS AND HOUSINGS FOR GAS AND WATER VALVES.

INSURANCE OF COMMODITIES IN THE UNITED KINGDOM.—With the approval of the Treasury, the Board of Trade has decided that, in respect of the period beginning September 3, 1941, and ending December 2, 1941, the rate of premium payable under any policy of insurance issued under the Commodity Insurance Scheme, War Risks Insurance Act, 1939—Part II, shall continue to be at the rate of 7*s.* 6*d.* per cent. per month.

INSTITUTION OF CIVIL ENGINEERS OF IRELAND.—In order to encourage the younger members of the Institution of Civil Engineers of Ireland to prepare papers on their work or their specialised engineering studies, Professor H. N. Walsh, M.E., President of the Institution, is offering a medal which the Council will award for the best paper submitted in the session 1941-42 by a young associate member or by a student of the Institution. The age limit for associate members is 30 years on January 1, 1942. Papers, which should be original communications, need not exceed about 2,500 words in length, and, at the outset, diagrams need only be in sketch form. The choice of subject is left to the competitors, and it is pointed out that the magnitude of the work is not the main criterion. For a short paper, a small work, described in detail, may be more suitable than an outline treatment of a larger work. Papers should be in the hands of the Registrar of the Institution, 35, Dawson-street, Dublin, by March 31, 1942. The winning paper, and any others judged to be suitable, may be read at a meeting of the Institution and published in the *Transactions*.

AMERICAN SOCIETY FOR TESTING MATERIALS.

ON page 154, *ante*, we gave a general account of the 44th annual meeting of the American Society for Testing Materials, held in Chicago from June 23 to 27. We now propose to give brief summaries of some of the more important reports and papers presented during the course of the meeting.

EFFECT OF TEMPERATURE ON STEEL.

Several committee reports, relating mainly to the issue of new specifications, and a number of interesting technical papers were considered at the session devoted to the subject of "Steel, Effect of Temperature." Mr. R. W. Emerson, the author of one of the papers, which dealt with "The Fabrication of Carbon Molybdenum Steel Piping for High-Temperature Service," pointed out that increasing amounts of hot reduction, by forging, resulted in improving to a remarkable degree any structural heterogeneity which might exist in carbon-molybdenum steel. The temperature at which the forging operation was discontinued determined the grain size of the steel. In some cases, structural heterogeneity persisted in carbon-molybdenum forgings, which, on account of their dimensions, could not be further hot worked. The structure of these, however, could be greatly improved by a thorough soaking at the appropriate heat-treating temperature, followed by air-cooling from that temperature. Two papers in this section were concerned with stainless steels, the first being entitled "A New Free-Machining Addition for Stainless Steels." The authors, Messrs. H. Pray, R. S. Peoples, and F. W. Fink, of the Battelle Memorial Institute, stated that small additions of bismuth, of the order of from 0·1 per cent. to 0·5 per cent., to the cast corrosion-resisting chromium and chromium-nickel alloys, with or without molybdenum, columbium or titanium additions, materially improved their machinability. Moreover, the bismuth addition did not affect, in any important degree, the mechanical properties and weldability of the stainless alloys; neither did it have any deleterious effect on the resistance of the alloys to attack by any corroding medium so far studied. Actually, in certain specific cases the resistance to corrosion of the materials was somewhat increased and their resistance to "galling" at high temperatures was improved. The laboratory data and results had been substantiated by plant and service tests.

The second paper on stainless steels referred to the determination of the stress-strain characteristics of cold-rolled austenitic stainless steels by a cylinder test method and was submitted by Messrs. R. Franks and W. O. Binder. The authors stated that the method was applicable to sections of sheet or strip

CAMSHAFT-HARDENING MACHINE.

MESSRS. SHORTER PROCESS COMPANY, LIMITED, SHEFFIELD.

(*For Description, see Opposite Page*).

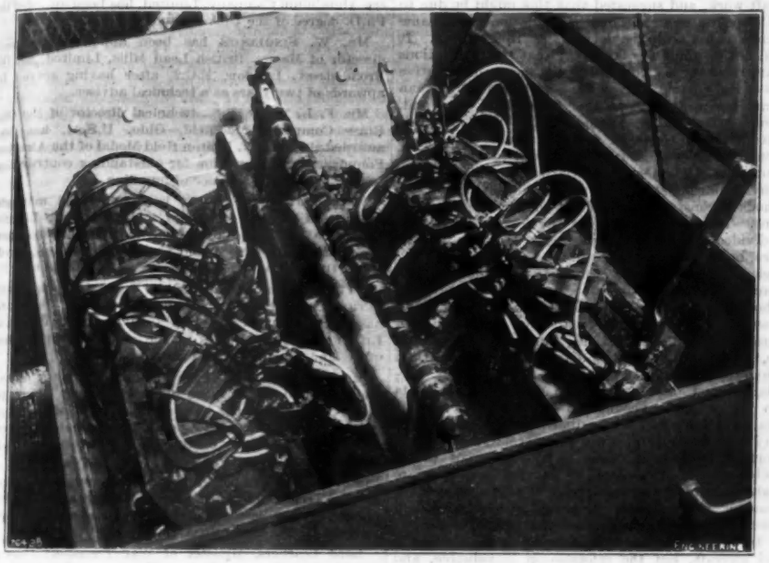


FIG. 2. CAMSHAFT IN POSITION AND BURNER GATES OPEN.

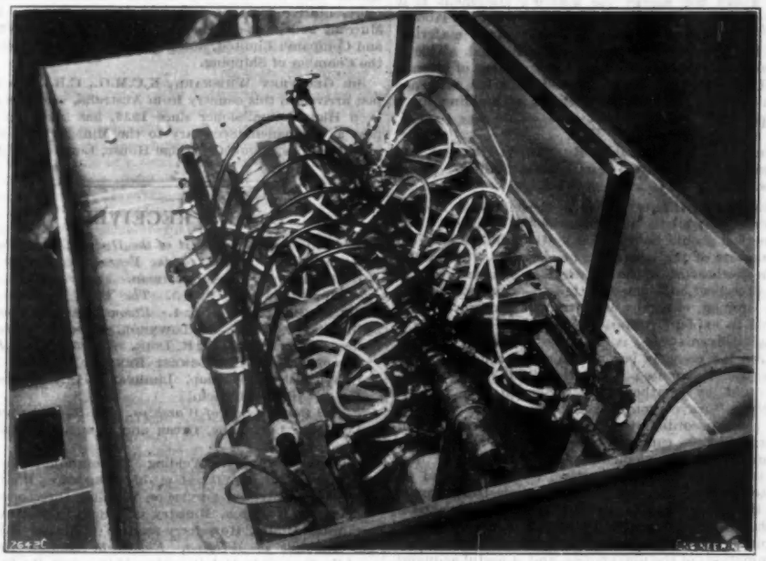


FIG. 5. MACHINE READY FOR OPERATION.

material ranging from 0·01 in. to 0·06 in. in thickness, and that it could probably be applied to thinner or thicker sections if suitable test specimens were designed. A knowledge of the compressive stress-strain characteristics of the sections of cold-rolled stainless steels was important in view of the application of these materials in light-weight high-strength structures, such as railway rolling stock, road-vehicle trailers and aeroplanes. The method of test consisted in cold-forming the strip or sheet into cylinders, having an appropriate "slenderness" ratio and diameter-to-thickness ratio, so that, when tested in compression, failure was symmetrical to the axis. Properly designed specimens could be loaded beyond the yield strength of the material without failing prematurely owing to local instability, and the yield strength, as determined by the 0·2-per cent. offset method, could be obtained. The 17-per cent. chromium, 7-per cent. nickel steels showed better compressive properties, when tested parallel to the direction of rolling, than did the 18-per cent. chromium, 8-per cent. nickel steels, particularly when the materials were cold-rolled to give a tensile strength in excess of 67 tons per square inch.

CORROSION AND FATIGUE OF IRON AND STEEL.

An extensive report, presented by Committee A-5, on the corrosion of iron and steel, was considered at a session devoted to problems involving the corrosion of iron and steel and fatigue questions. Perhaps the most important section of the report was that dealing with the data submitted by the Wire Inspection Committee on field tests of fence wire, farm-field fencing, and other wire products, involving the exposure of specimens for about four years at each of 11 corrosion stations; at each station, upwards of 900 specimens were exposed. From the results obtained the committee had drawn four tentative conclusions. The first of these was that, on zinc-coated specimens the degree of protection increased with increase in the weight of the coating. Secondly, the rate of loss of the coating on zinc-coated specimens was greater on the small-diameter wires than on the large diameter wires. Thirdly, the rate of loss of the base metal was more rapid on the smaller-diameter wires than on the larger-diameter wires. In the fourth place, the relative rate of corrosion at Pittsburgh was approximately six times that at State College, Pennsylvania, while the corrosion rates at Bridgeport, Connecticut, and at Sandy Hook, New Jersey, were about twice that at State College.

Of the papers dealing with fatigue, one by Mr. W. M. Murray and Professor J. M. Lessells related to "The Effect of Shot Blasting and its Bearing on Fatigue." The authors concluded that a considerable increase in the fatigue life and endurance limits of steels could be obtained, under certain conditions, by shot-blasting the surface. Moreover, it could be inferred that similar advantages might be gained in the case of metals other than steel. The increase in fatigue life and endurance limits seemed to be due to a cold-working of the outer surface, and the compressive stress resulting from the shot blasting might also be beneficial. Apparently, however, no advantage was gained, as regards endurance limit, by shot-blasting surfaces when high residual stresses, due to quenching and inadequate tempering, were present. The beneficial effects of the treatment were removed by annealing, but, on the other hand, a low-temperature annealing treatment further increased the fatigue life of shot-blasted surfaces. Another paper in this section was entitled "Pitting and its Effect on the Fatigue Limit of Steels Corroded under Various Conditions." The authors, Dr. D. J. McAdam and Mr. G. W. Geil, stated that they had made a study of the form, size, and distribution of the pits caused by the corrosion of steels in streams of well water, river water, distilled water, softened water and a Normal salt-water solution. Pits in the steels tended to be roughly hemispherical at first, but they afterwards changed to a saucer-like form and spread irregularly along the surface. This change was more rapid in the case of carbon steels than in that of 3½-per cent. nickel and other alloy steels. Carbon steels, especially during corrosion in the salt spray, tended to form sharp root-like projections at the bottoms of rounded corrosion pits. The tendency for such projections to form was less in the case of alloy steels. Cyclic stress effects accelerated corrosion pitting. When the combined influence of stress, cycle frequency, and corrosion time was sufficiently great, the cyclic stress caused round or irregular pits to extend in a transverse direction, with the development of crevices or fissures.

CAST IRON.

An important matter discussed in the session on cast iron was the report of Committee A-3, which included data on a recommended practice for evaluating the microstructure of graphite in grey iron. The proposals put forward in the report involved the classification of the flake graphite on grey cast iron by comparison with two charts illustrating standard structures. The graphite-flake size chart showed eight graded flake lengths photographed at 100 diameters and a corresponding set of "idealised" diagrams for alternative use. Each of the eight microphotographs represented as nearly as possible a perfect example of graphite-flake lengths within the range of lengths covered. It was emphasised that, as the graphite particles were saucer-shaped, the plane through which each particle was cut determined its apparent length and this apparent length might vary from zero to the actual length of the major axis of the flake. Accordingly, maximum flake length had been used as the criterion in selecting the examples chosen for each size. The graphite-flake type chart showed five types of graphite-flake structure with respect to distribution and orientation and this enabled structures to be classified according to the arrangement, as well as the size.

In a paper entitled "The Strain-Hardening of Grey Cast Iron," Mr. J. S. Peck gave an account of the effect produced on the Rockwell hardness value of this material by compressive loads of increasing intensity. The specimens of grey cast iron employed measured 1 in. square, by ½ in. high. The results showed that with loads of up to about 18 tons per square inch the Rockwell B hardness value increased slightly. With loads of from 18 tons to about 27 tons per square inch no significant change in the hardness value was observed, but further increases in the compressive load from 27 tons per square inch to the failure of the specimen caused a rapid decrease in the Rockwell B hardness value. In order to explain this apparent violation of all the theories of strain-hardening, microphotographs were made of the same spot on one specimen after increasing compressive loads had been applied. These showed that after minute cracks appeared in the material after the application of a load of 27 tons and that successive loads intensified the cracking until failure occurred. It was concluded that the apparent softening of the metal was due to the fact that the indenter of the machine entered one of these minute fissures and gave a lower reading.

ATMOSPHERIC POLLUTION.

THE Department of Scientific and Industrial Research has announced that the various bodies co-operating in the study of atmospheric pollution have agreed to a proposal to suspend publication of the annual reports for the duration of the war. The suspension applies to the 26th annual report for the year ended March 31, 1940, but, for the information of the cooperating-organisations, a summary of the work done during that year has been prepared by the Superintendent of Observations. This shows that the numbers of instruments maintained were as follows: deposit gauges, 127; automatic filters, 11; volumetric sulphur apparatus, 12; lead-peroxide apparatus, 60. On the outbreak of war, observations with some instruments were discontinued; in most cases, however, only temporarily.

The results obtained with the deposit gauges, as summarised by the figures for total solids deposited, were as follows, the results for the previous year being given in brackets in each case: Class A, 31 (26); Class B, 69 (72); Class C, 0 (1); Class D, 0 (0). This shows that, in the year under review, there was an increase in the number of stations where the deposit ranked as Class A; in other words, the deposit over the whole country, as measured by the gauges, had decreased. This result continues the improving trend indicated by the diagram, Fig. 1, on page 88 of the previous annual report. The highest total deposit measured during the year (395 tons per square mile) was recorded at Manchester, and the lowest (57 tons) at Loggerheads. Both of these figures were less than the corresponding recordings in the previous year.

There were only three complete sets of results with automatic filters, namely, those from Cardiff, Coventry and Stoke-on-Trent, and these alone are insufficient to provide a basis for comparison with previous figures; but the average monthly suspended impurity does show interesting characteristics (notably maxima) in January, 1940, which was unusually cold. This increase in suspended impurity was due, undoubtedly, to increased domestic heating, despite local shortages of fuel. All three places show such an increase in October, followed by a minimum in November, although the average temperature for that month was lower than the average for some 50 years. It is conjectured that the extension of Summer Time until November 20, 1939, and the restrictions imposed by the fuel rationing scheme, were responsible to some extent for the minima recorded during that month. Complete results for the measurement of sulphur-dioxide concentration by the volumetric method were obtained from the stations at London (Beckton and Crossness), Salford and Sheffield. The averages were slightly lower than those for the previous year. The measurement of sulphur gases by the lead-peroxide method did not show any unusual features.

Measurements of suspended impurity made in Central Park, New York City, by means of the automatic filter, showed that the air was purest between 1 p.m. and 3 p.m., whereas the measurements for British cities have invariably shown that the early morning air was the cleanest. This difference is presumed to be due to the greater convectional turbulence of a continental climate in the day time, resulting in a distribution of the pollution through a greater depth of atmosphere, and a corresponding reduction in the concentration at ground level. Further measurements made in Dublin showed an interesting correspondence between the concentration of sulphur dioxide and the suspended impurity, the two curves of average monthly values showing noticeable parallelism. Results with the automatic filter at Leinster Lawn, Dublin, indicated a ratio of domestic to industrial pollution of 3·3 to 1 in winter and 2·3 to 1 in summer.

DRIVING-BELT CONDITIONING.—The loss of efficiency, decrease in tensile strength, and increased wear attendant on running a flat driving belt in a "dry" condition, is informatively discussed in some technical data sheets recently issued by the Research Department of Messrs. Revol, Limited, 97, Quayside, Newcastle-upon-Tyne, 1. The condition referred to is that obtaining when the natural oils in the belt have been eliminated by atmospheric reaction and the heat arising from the friction between the belt and the pulley, when glazing and hardening of the belt surface results. It is claimed that the neutral axis of the belt is virtually moved in towards the pulley when the material is maintained in a pliable condition, that is, the outer layers, in which extension takes place round the pulley on the driving strand, have sufficient elasticity to minimise the wrinkling due to compression on the inner layers, so that slip is minimised. The treatment advocated is the periodic use of a light oil without mineral content or resinous base, and having the characteristics of extremely slow evaporation and high heat resistant value. The oil is applied from a long-spouted can so that, since there is no contact with the belt, the operation is quite safe.

NOTES ON NEW BOOKS.

Metal Aircraft Construction. By M. LANGLEY. Fourth edition. London: Sir Isaac Pitman and Sons, Limited. [Price 15*s.* net.]

THE review of the third edition of this book, in ENGINEERING of October 12, 1934, page 394, commented upon the scarcity of information on American aircraft work, and suggested that this might be due to the United States air authorities' regulations. The same criticism can hardly be levelled at this edition. It would not be going too far to say that the descriptions of American types constitute the most informative parts of the volume. Even the descriptions of German aircraft are up-to-date to the outbreak of war, and, although the author apologises for not including matter relating to those captured since then, it is doubtful whether there is much to add to what he has already said. The technical design of German aircraft has by no means stood still during the war, but their methods of construction have not changed to any great extent. The main portions of the descriptive matter are divided into chapters dealing with main planes, bodies, boat hulls and floats, and subsidiary structures; a logical division, as the problems of design are quite different in these separate items, and the optimum method of construction for one might be quite wrong for another. These chapters are well provided with diagrams, most of them of the perspective-sketch type, which bring out the details more clearly than photographs. The discussion on fuel tanks is particularly good, and contains many facts and hints upon the problems peculiar to the design of aircraft tanks that have not been published elsewhere. It is a pity that the author is not so informative upon the important subject of crash and bullet-proof tanks. Possibly reasons of secrecy, or the fact that they are not always made from metal, have been the cause of the omission. The chapters on materials and workshop processes deal with many points that should not logically be included in a discussion upon the design of metal aircraft, but the information is valuable, and it is useful to have it placed on record. Incidentally, there are people in the steel and the copper industries who would not accept the author's statement that "beryllium is still almost unknown beyond the laboratory," although it is true in so far as the materials used for aircraft construction are concerned. This is a book that should be read by every student of aircraft detail design, and should be valuable for reference when considering possible methods of building up a new part.

Intermediate Electricity. By ROBERT W. HUTCHINSON. London: University Tutorial Press Limited. [Price 12*s.* 6*d.*]

A FEATURE of this text-book is the emphasis laid on the view that all the manifestations of electricity and magnetism should be regarded by the student as different aspects of the behaviour of electrons. The Bohr-Rutherford theory of the constitution of atoms is therefore described at some length in the opening pages, and, later on, electrons are introduced wherever practicable to explain various phenomena. Praiseworthy though this may be, it must be admitted that the electron has recently become even less comprehensible than the discredited "electric fluid," for we are now told by mathematical physicists that it is merely a "wave group" (whatever that may mean), and that, according to Heisenberg's principle of indeterminacy, it can never be anywhere in particular at any time. The elementary student, however, need not trouble about such matters, for he can read the greater part of the volume without electrons coming into the picture at all. By the time he has finished it, he should have a greater knowledge of electricity and magnetism than is required for the intermediate science examinations of the universities, and a useful acquaintance with the principles of X-rays, wireless telephony, and television. The book is clearly written, well illustrated, and contains no more mathematics than such a reader may be presumed to understand. It is indeed an excellent example of a modern text-book, though covering, for the most part, ground that has formed the subject of almost innumerable books in recent years.

PETROLEUM PRODUCTION IN THE UNITED STATES.—The daily output of crude oil in the United States during the week ending August 16 constituted a new high record. It was 3,953,300 barrels, against 3,911,950 barrels in the previous week.

REGISTRATION OF BUILDERS AND CONTRACTORS.—We are informed that builders and civil-engineering contractors who were unable to obtain application forms for the purpose of registration may now secure them, as fresh supplies are being distributed. The forms should be completed and returned as soon as possible, the latest date for their receipt being Friday, September 12.

PERSONAL.

MR. G. H. INCE, C.B., director general of man-power, Ministry of Labour and National Service, has been appointed to represent that Ministry on the Central Council for Works and Building.

MR. R. T. PARKER, B.Sc., A.R.S.M., research metallurgist, Research and Development Department, Northern Aluminium Company, Limited, has been awarded the Ph.D. degree of the University of London.

MR. W. SINGLETON has been appointed technical director of Messrs. British Lead Mills, Limited, 69, Old Broad-street, London, E.C.2, after having served for upwards of two years as a technical adviser.

MR. F. L. WOLF, B.S., technical director of the Ohio Brass Company, Mansfield, Ohio, U.S.A., has been awarded the John A. Penton Gold Medal of the American Foundrymen's Association for outstanding contributions to the science and practice of founding.

MR. R. J. BARCLAY has been appointed managing director of Messrs. Markham and Company, Limited, Broad Oak Works, Chesterfield, a subsidiary company of Messrs. John Brown and Company, Limited, Clydebank, Dumbartonshire.

As from August 22, the name of THE FRANCOIS CEMENTATION COMPANY, LIMITED, Bentley Works, Doncaster, has been changed to THE CEMENTATION COMPANY, LIMITED. The addresses of the registered office, head office, and London office remain as before.

MR. C. L. DYER has been appointed director of tank materials and construction at the Ministery of Supply. MR. C. B. COWLEY has been made director of tank components, and MR. J. D. CROKER co-ordinating director and principal advisory engineer to the director-general of tank supply.

MR. W. J. PARSLOW, director and general manager of Messrs. Tecalemit, Limited, Great West-road, Brentford, Middlesex, has been appointed joint managing director to act with MR. R. A. CHALMERS.

Lord Leathers, Minister of War Transport, has appointed MR. ERNEST HENRY MURRANT, M.B.E., to be special Ministry of War Transport Representative in the Middle East to collaborate with the Ministry's existing representative for that area, SIR HENRY BAKER. Mr. Murrant is deputy chairman of Messrs. Furness, Withy and Company, Limited, and a member of the Council of the Chamber of Shipping.

SIR GEOFFREY WHISKARD, K.C.M.G., C.B., who has just arrived in this country from Australia, where he has been High Commissioner since 1936, has taken up his post as Permanent Secretary to the Ministry of Works and Buildings, Lambeth Bridge House, London, S.E.1.

BOOKS RECEIVED.

Thirty-Third Annual Report of the Hydro-Electric Power Commission of Ontario for the Year Ended October 31, 1940. Toronto: T. E. Bowman.

Post-War Questions. No. 3. *The Profit Motive.* By SIR ERNEST BENN. No. 4. *Reconstruction of Bombed Buildings.* By B. S. TOWNROE. No. 5. *Possible Recovery.* By DR. W. R. INGE. No. 6. *The B.B.C. Monopoly.* By SIR ERNEST BENN. London: The Individualist Bookshop, Limited, 154, Fleet-street, E.C.4. [Price 6*d.* each.]

Practical Construction of Warships. By R. N. NEWTON. London: Longmans, Green and Company, Limited. [Price 21*s.* net.]

Ministry of Supply. Welding Memorandum No. 4. *Memorandum on the Use of Resistance Welding.* London: Advisory Service on Welding, Directorate of Scientific Research, Ministry of Supply, Great Westminster House, Horseferry-road, Westminster, S.W.1.

The Institute of Welding. Eighteenth Annual Report of the Council to 31st December, 1940; with the Fourth Progress Report of the Welding Research Council. London: The Institute of Welding, 2, Buckingham Palace-gardens, Buckingham Palace-road, Westminster, S.W.1.

United States Geological Survey. Water Supply Paper No. 877. *Surface Water Supply of the United States, 1939. Part 7. Lower Mississippi River Basin.* Washington: Superintendent of Documents. [Price 45 cents.]

THE LATE LIEUT.-COL. SIR E. KEITH NUTTALL.—It is with regret that we record the death, on active service, of Lieut.-Col. Sir Edmund Keith Nuttall, Bt., Royal Engineers. He was the chairman of the firm of Edmund Nuttall, Sons and Company, Limited, civil-engineering contractors, Trafford Park, Manchester, 17, and 22, Grosvenor-gardens, London, S.W.1. He was born on March 27, 1901, and educated at Brighton College and at Clare College, Cambridge. He succeeded his father as second baronet in 1923, and became an associate of the Institute of Civil Engineers in 1932.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Welsh Coal Trade.—Problems, concerned with the return to the mines of ex-miners who had left the district, continued to attract a good deal of attention in the Welsh steam-coal trade during the past week. At a meeting of the South Wales Miners' Federation executive council the question was discussed and it was announced that it had now been agreed to pay the men from the day they were signed on by the colliery companies; travelling expenses would be paid by the Ministry of Labour. So far about 1,800 men had returned to the mines in this district from other jobs, and it was expected that some 7,500 would ultimately return. It was the intention of the Council to suggest to the coalowners that steps be taken to provide the men with tools immediately on their return to the pits. Many of them had been placed in employment at considerable distances from their homes or lodgings, and the Federation proposed that travelling expenses should be met from the national pool which had been formed to meet the charges arising from the Essential Work Order. The steam-coal market continued to present a very firm tone during the week. The demand in both the home and export sections was sustained but little new business could be undertaken for early delivery. Most collieries already has sufficient orders on their books to ensure the absorption of almost the whole of their outputs for some time to come and the market therefore remained very firm. Best large descriptions were absorbed by the orders on the producers' books and but little of the sized grades were on offer. A very strong tone ruled for the bituminous small grades which were almost completely sold for some considerable time ahead and the few odd lots which salesmen had to offer found ready outlets. Some of the inferior dry steam smalls were fairly readily obtainable for early delivery and were consequently dull. Cokes were busy while patent fuel was unchanged.

The Iron and Steel Trade.—Active conditions were maintained in the iron and steel and allied trades of South Wales and Monmouthshire, with the exception of the tin-plate trade which was quiet as a result of the official restrictions.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—Conditions in the Scottish steel trade have varied little during the week. Although there is a large amount of work on hand against Government contracts new business is rather quiet. This, however, is only of a temporary nature. Meantime production is being maintained at the recent high level. Shipping material is in strong demand for the new tonnage on order. Light material is dull and black steel sheet makers would welcome further orders. Stocks of raw materials are adequate at the moment, but efforts are being made locally to gather in as much steel scrap as possible. The following are the current quotations:—Boiler plates, 17*l.* 12*s.* 6*d.* per ton; ship plates, 16*l.* 3*s.* per ton; sections, 15*l.* 8*s.* per ton; medium plates, ¼ in. and thicker, rolled in sheet mills, 21*l.* 15*s.* per ton; black-steel sheets, No. 24 gauge, 22*l.* 15*s.* per ton; and galvanised corrugated sheets, No. 24 gauge, 26*l.* 2*s.* 6*d.* per ton, all for home delivery.

Malleable-Iron Trade.—In the West of Scotland malleable-iron trade there has been some improvement in the demand and makers are well placed with business at present. There is some shortage of scrap and this makes it somewhat difficult to keep the furnaces operating at full capacity. The re-rollers of steel bars are rather quiet, as many old contracts have been cleared off and new Government contracts are coming along slowly. Supplies of semies are still good. Prices are steady and are as follows:—Crown bars, 15*l.* 12*s.* 6*d.* per ton; No. 3 bars, 13*l.* 12*s.* 6*d.* per ton; No. 4 bars, 13*l.* 17*s.* 6*d.* per ton; and re-rolled steel bars, 17*l.* 15*s.* per ton, all for home delivery.

Scottish Pig-Iron Trade.—There has been no slackening in the demand for Scottish pig-iron and makers are being pressed for deliveries. Steelmakers are in need of hematite and basic iron and every endeavour is being made to keep up supplies. The demand for foundry grades of iron has improved and a fair tonnage is being delivered. Stocks of iron ore, for the meantime, are good. To-day's market quotations are as follows:—Hematite, 6*l.* 18*s.* 6*d.* per ton, and basic iron, 6*l.* 0*s.* 6*d.* per ton, both delivered at the steel works; foundry iron, No. 1, 6*l.* 5*s.* 6*d.* per ton, and No. 3, 6*l.* 3*s.* per ton, both on trucks at makers' yards.

AMERICAN COLLIERY INDUSTRY.—The production of bituminous coal in the United States during the week ended August 16 averaged 1,783,000 tons daily, compared with 1,758,000 tons in the preceding week and 1,491,000 tons in the corresponding week of 1940.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

General Situation.—There is still a shortage of iron and steel for general industrial undertakings, but the supply for Government requirements is adequate. A considerable curtailment of the imports from the United States, to free tonnage for other urgent needs, has not reduced the distribution of North East Coast products, and the works in this area continue to be actively employed. The rationing of consumers of certain descriptions of material, however, is still unavoidable. Raw materials are plentiful and semi-finished products are in ample supply.

Cleveland Iron Trade.—The continued scarcity of Cleveland pig is of little consequence, as supplies of foundry iron from other producing areas are ample for all purposes. Delivery licences are issued fairly freely and there is virtually no restriction of distribution. The fixed prices of Cleveland pig are based on No. 3 description at 128*s.* delivered in the Middlesbrough district.

Basic Iron.—There is still no saleable basic iron, the nominal price of which remains at 120*s.* 6*d.* The output is maintained at a level that fully covers the requirements of the producers' own steelworks and provides occasional small parcels for stock.

Hematite.—The supply of hematite is still less than the demand and the continued use of substitutes wherever possible is necessary. Official quotations remain at the equivalent of No. 1 grade of iron at 138*s.* 6*d.* delivered to North of England buyers.

Foreign Ore.—Satisfactory cargoes of most kinds of foreign ore are arriving regularly, but there are still difficulties regarding the import of descriptions required for the production of hematite.

Blast-Furnace Coke.—The situation in the blast-furnace coke branch of trade confines transactions within narrow limits but is not unsatisfactory. The consumption is heavy and the supply abundant, but local users are extensively covered and sellers are disinclined to enter into new contracts until they have materially reduced their delivery obligations. The recognised market value of Durham good medium qualities is 36*s.* 9*d.* f.o.r.

Manufactured Iron and Steel.—The tonnage of semi-finished iron and steel held by re-rollers is substantial and the delivery of local products continues on a satisfactory scale. The aggregate output of finished commodities is exceptionally heavy and producers of most descriptions of material have a great deal of work in hand. Manufacturers of structural steel, however, could handle more orders. Sheet makers are still very busy but buyers are less inclined to negotiate than has been the case for some time. The demand for ship, tank and boiler plates is unabated and pressure for larger supplies of special-alloy steels is increasing. Available parcels of railway material are promptly taken up.

Scrap.—Large tonnages of scrap are passing into consumption, but the demand continues particularly for machinery metal, heavy cast iron and heavy steel.

THE LATE DR. R. D. ARCHIBALD.—We note with regret the sudden death of Dr. Robert Douglas Archibald, which took place on August 17. Dr. Archibald, who retired only a short time ago from the position of senior lecturer in electrical engineering at the Royal Naval Engineering College, Keyham, Plymouth, which he had held since 1923, was born on July 2, 1881. He was educated at Kelvinside Academy, Glasgow, and from 1898 to 1900 was an apprentice fitter in the works of The Fairfield Shipbuilding and Engineering Company, Limited, Govan. In 1900 he entered the Royal Technical College, Glasgow, and gained the Associateship of the College, in electrical engineering, in 1903. After completing his studies at Glasgow University he was awarded the B.Sc. (Eng.) Degree in 1904, afterwards receiving the D.Sc. (Eng.) Degree. Meanwhile, his summer vacations of 1901, 1902 and 1903 were spent in the works of Messrs. Mavor and Coulson, Limited, Glasgow, for part of the time as apprentice patternmaker, and also as armature winder and tester. In 1904 he was appointed to the staff of the Electric Construction Company, Limited, Wolverhampton, where he gained valuable experience in the manufacture and testing of electrical machinery of all types. Subsequently he returned to the Royal Technical College, Glasgow, as chief assistant in the Electrical Department and later became head of the Electrical Department of the Technical College, Dundee. After acting for some time as extra-mural lecturer of St. Andrew's University, he was appointed to his ultimate position at Keyham. During the war of 1914–18 he served in the Royal Garrison Artillery, attaining the rank of Staff Captain and being mentioned in dispatches. He was elected an associate member of the Institution of Civil Engineers in 1907 and of the Institution of Electrical Engineers in 1909. He became a member of the latter institution in 1920.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—To find work for idle machinery, Sheffield Chamber of Commerce has appealed to its members to support a Capacity Clearing Centre, which has been set up in the city. The Chamber states that in every factory, through unbalance of plant, irregular flow of orders, delay in receipt of materials, etc., small, or sometimes large, blocks of spare capacity occur in the load on machines. A Capacity Clearing Centre has been set up at the office of the Production Executive, East and West Ridings Regional Board, Fargate House, Fargate, Sheffield, 1, with the object of taking overloads to factories with spare capacity. The success of the new plan involves two essentials: (1) firms having spare capacity must notify the fact, and (2) firms needing capacity must ask for it through the Centre. The organisation is new to the East and West Ridings of Yorkshire, but has already been tested in the South, where it is now working very satisfactorily. Detailed records of the machines held by firms are kept, and with these are notes, compiled from information sent in by firms, regarding idle or semi-idle machines. If there is any work to place, the Centre is able to tell at a glance where the appropriate machines are and whether any of these are free or will be free. Special forms have been designed for those wishing to offer capacity and those requiring it; supplies of these forms are available on application to the Secretary of the Regional Board. The types of machines in which the Centre is primarily interested include lathes, vertical turrets, boring machines, grinding machines, milling machines, planing machines, shaping machines, slotting machines, gear-cutting machines, broaching machines, drilling machines, filing and sawing machines, watch-making machinery, plate-working presses, and die-sinking machines. The general idea anticipates linking up industries throughout the Kingdom, once the various Regional pools are established. Having invited co-operation, there is one brief comment to add. It does not necessarily follow, of course, that spare capacity can be always and instantly employed. The general condition of the staple trades shows no material change. There is a strong flow of orders on war account, and many firms are supplying record tonnages of products. Some of these concerns are so hard pressed that difficulty is being experienced in meeting the requirements of ordinary commercial customers. Supplies of raw materials are adequate. Imports of pig iron, foundry iron, and hematites are on a large scale, and a satisfactory state exists regarding scrap; labour shortage, however, is retarding the collection of some types of scrap, and scrap merchants have plenty of work to offer to men skilled in the sorting of metals. There is a heavy demand for all types of alloy steels. Producing works are able to keep pace with requirements in this respect owing largely to the foresight they showed in pre-war days in installing large batteries of electric and open-hearth melting plants. All types of machinery are in request. Boiler makers are busy and large hollow-forged boiler drums are in demand for a variety of purposes. Many of these drums have been ordered by firms carrying out extensions to electric power stations in various parts of the country. Engineers' small tools are in strong demand.

South Yorkshire Coal Trade.—Municipal and industrial undertakings are building up stocks of all types of coal. The demand from engineering works shows a steady rise over the past few months. Steam coals are in active request, and smalls and slacks are moving off in large tonnages to electric power stations and gas works. The house-coal market is more active; southern consumers, in particular, are taking larger supplies. Foundry and furnace cokes are in demand.

MOTOR LIFEBOAT IN BAY OF DONEGAL.—A new lifeboat station has been opened at Killybegs, on the Bay of Donegal, by the Royal National Life-Boat Institution, and a new motor lifeboat has arrived there.

AUSTRALIAN EXPORT PROHIBITIONS.—A proclamation published in a recent issue of the *Commonwealth Government Gazette* prohibit the export from Australia of certain specified ores and concentrates, and machinery and metals, except with the consent of the Minister of Trade and Customs. A list of the items concerned may be seen by persons interested at the Department of Overseas Trade, Millbank, London, S.W.1.

SWANSEA METAL INDUSTRY.—The current market report of the Incorporated Swansea Exchange states that conditions on the Swansea tin-plate market are relatively quiet, business being chiefly confined for the present to dealings with home consumers. Furthermore, the demand for galvanised steel sheets is not so urgent as a number of priority orders have now been completed. Business in iron and steel scrap is not so brisk.

DISTRICT HEATING IN DETROIT.

(*For Description see page* 183).

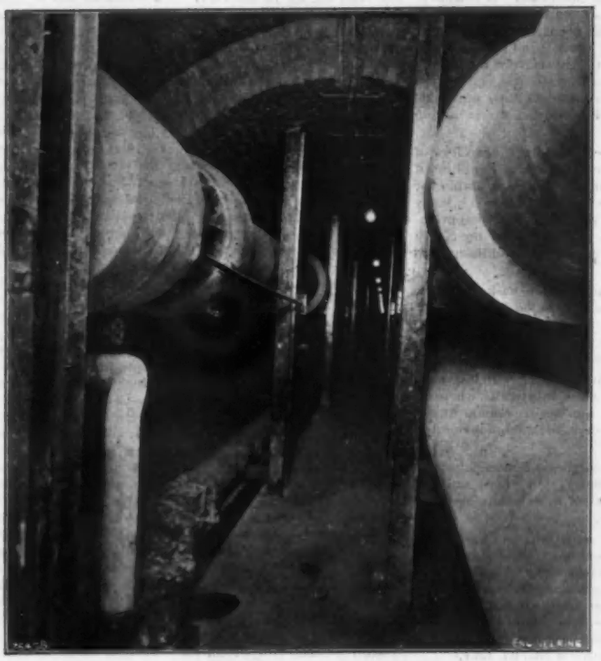


FIG. 3. HIGH-PRESSURE STEAM MAINS.

FIG. 4. STANDARD METHOD OF LAYING 12-IN. MAINS.

FLUXES FOR SOFT SOLDERS.

AN interim report on a research which is being conducted in this country as well as in the United States, with the object of finding a really non-corrosive flux that effectively prepares metals for soft soldering, is contained in a recent publication of the Tin Research Institute. The authors of the report, Mr. H. Peters and Dr. B. Gonser of the Battelle Memorial Institute, Columbus, Ohio, U.S.A., state at the outset that zinc chloride, the "time-honoured" flux, is effective when used with most metals, but it frequently leaves a corrosive residue, even after washing repeatedly with water. Similarly, the various inorganic and organic acids and chloride salts used as fluxes are often not entirely satisfactory in view of their liability to attack the parent metal. At the other end of the scale rosin, while non-corrosive, is judged not to be an effective flux except when used on relatively clean tin-plate and copper. It is pointed out that it does not flux steel or oxidised copper, does not promote spreading of the solder and is rather difficult to remove. Consequently, recent research has been directed towards organic materials which, while substantially non-corrosive when cold and leaving water-soluble residues, can decompose—when heated during soldering—to release an active, oxide-dissolving constituent.

One of the many difficulties encountered in developing an improved flux is to find means of testing which give results of practical value. Obviously, it would be inconvenient and cumbersome to make a large number of joints using one flux, and to attempt to compare the strength, ease of joining, and other contributory factors, with joints similarly prepared with another flux. On the other hand, it is possible to obtain indications of the qualities of the fluxes under examination by comparing certain of their properties, such as the effect of each flux on the surface tension, or "flowability," of the solder; its effectiveness in removing oxide films; and whether or not, and to what extent, it corrodes the bare metal. Employing this procedure, a wide range of possible fluxes may be tested, and those which show distinct promise can be subjected to a more rigorous examination subsequently. The procedure adopted in the present research was to note the general fluxing characteristics of a large number of materials when spot-soldering specimens of No. 14-gauge oxidised copper sheet and slightly-rusted cold-rolled steel strip. By using exactly the same amount of solder in each case and maintaining all conditions similar, except the flux, it was possible to evaluate the flux qualitatively and to compare it with rosin and zinc chloride as standards, the former being rated as a "fair" and the latter as an "excellent" flux. Some of the organic acids, such as oleic and stearic acids, were active as fluxes but were decidedly corrosive. Moreover, neutralisation with alkalis, such as caustic soda, to form a soap, did not eliminate their tendency to corrode. On the other hand, neutralisation with ammonia or with an organic base such as an amine offered interesting possibilities. In fact, some of the amines and amides—for example, ethylene diamine and acetamide—have been employed as fluxes to a limited extent. Recent investigations have been concerned with ammonium and amine salts of stearic, oleic and palmitic acids and particularly those of stearic acid. Many of these salts have been found to be good fluxes for copper; some have appeared to be non-corrosive, while a few effectively flux steel.

The stearic-acid salt of diethylene triamine appeared to be particularly attractive as a flux for both copper and iron. Not only did it prove an excellent and effective flux, but it did not decompose unduly and gave a residue which was as non-corrosive as rosin. Unfortunately, however, this substance has a disagreeable odour; hence it may not be suitable where good ventilation is not available. The oleic-acid salt of diethylene triamide was also found to be an effective flux on steel and copper, although it was more corrosive than the stearic-acid salt. Unlike zinc chloride, however, it was not hygroscopic and was completely soluble in water without the formation of an insoluble oxy-salt. Stearamide, produced by heating the ammonium salt of stearic acid, was found to be an excellent flux for copper and gave evidence of only slight attack of the parent metal while heating during the soldering operation. One of the drawbacks of employing the amine type of flux is the cost of these products, but in view of the progress made during the past few years in the synthetic production of the amines, it is possible that their application will become increasingly practicable in industrial soldering operations.

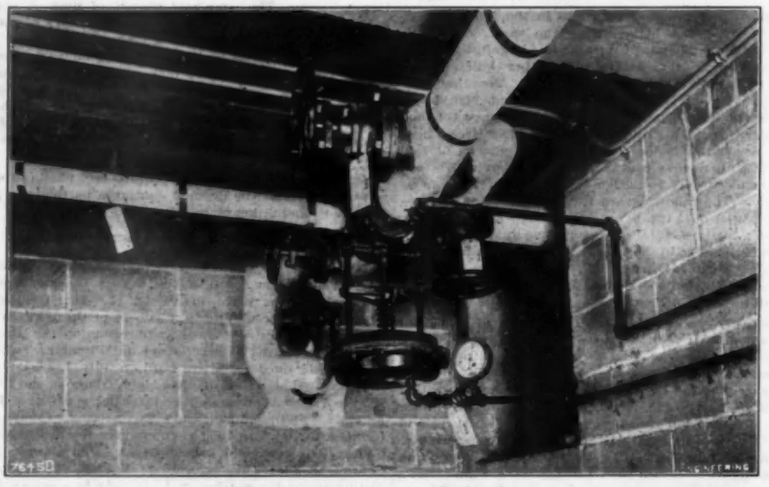


FIG. 5. STEAM-CONTROL VALVES IN BUILDING.

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TELEPHONE NUMBER—TEMPLE BAR 3663 (2 lines).

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Classified advertisements intended for insertion in the current week's issue must be delivered not later than first post on Wednesday. Alterations to standing advertisements must be received at least 10 days previous to the day of publication. Passed proofs must be in our hands by Saturday morning, otherwise they will be taken as correct. The Proprietors will not hold themselves responsible for blocks left in their possession for more than two years.

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For the duration of hostilities, the Editorial and Publishing business of this Journal is being conducted from 18 and 20, Compton Road, Hayes, Middlesex. The Telephone Number of the Editorial Department is Hayes 1730, and that of the Publishing Department, Hayes 1723. The Bedford Street Offices are open on Fridays only, between 10 a.m. and 5 p.m., for the distribution of the current issue and for retail sales.

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ENGINEERING

FRIDAY, SEPTEMBER 5, 1941

VOL. 152. No. 3947.

PROBLEMS OF MANPOWER.

As the war enters upon its third year, it is becoming increasingly evident that one of its main problems is that of manpower; partly in the military sense that was so prominent in the last war, but even more noticeably in the industrial field. In the absence of any precise statistics regarding the numbers of men in the combatant Forces of Great Britain and the Allies, it is not possible to state how many industrial workers of all grades, including the administrative staffs, are required to keep one fighting man in the field, but the indications are that the proportion has increased considerably since the previous war was fought, and that the increase is affecting both sides to approximately an equal extent. Germany is able to meet this demand by impressing the peoples of conquered and associated nations; Britain, and to a less extent, Russia, meet it by enlisting the aid of the other partners in the British Commonwealth and by drawing upon the resources of the New World. Neither side, however, is experiencing the relief forecast by some prophets, on the conclusion of the last war, who predicted that future wars, because they would be so much more mechanised, would not require the immense forces of troops that were raised between 1914 and 1918, mainly to be used in contesting the possession of relatively limited areas of ground.

The manpower problems of the present conflict are different from those of the last war for several distinct and separate reasons, and to a great extent are not so much questions of numbers only as of numbers in particular categories. This is especially true of industrial manpower, and is partly the result of the considerable changes that have taken place in the structure of industry during the past quarter of a century. The methods of the older manufacturers have changed, and new manufactures have been developed, some of which have proved to be even more essential in war than in peace; so that their personnel, instead of providing a reservoir of labour on which the older munitions industry could draw, has had to be augmented from time to time by progressive dilution. The construction and repair of barrage balloons, for instance, is occupying large numbers of women who under the conditions of the last war, would have been available for shell shops and filling factories; and the wider provision of works' and A.R.P. canteens has absorbed thousands more. Such changes as these are probably responsible to a greater extent than is commonly realised for the difficulty now being experienced in finding sufficient numbers of women to take their places in the new Government factories.

The shortage of skilled men is probably a result, in part, of the prolonged industrial depression and the consequent fall in the numbers of new apprentices to skilled trades. Associated with this drop, there is the undoubted decline in the opportunities for skilled craftsmen which has been a feature of mechanical industry for the past quarter of a century at least, and may be traced to the spread of quantity-production methods in trades, such as instrument-making, which formerly could command only a limited market. As the extent of mechanisation has increased, such manufactures have been "broken down" (in the phrase now current) into a succession of ever-simpler processes, most of them within the capacity of any reasonably intelligent person to perform, and calling for manual dexterity rather than the kind of skill that is acquired only by long experience. Indeed, it has become a commonplace that, in many forms of engineering manufacture of the present day, commercial success depends quite as much upon the efficient organisation of production as upon the excellence of the original design; to borrow a simile from the field of music, the function of the composer tends to become subordinated to the orchestration. This introduces no difficulty for the consumer or user of the product so long as proper arrangements can be assured for maintenance, but complications multiply if the user is suddenly expected or obliged to undertake maintenance himself.

This is the situation now confronting the Army and the Royal Air Force, and, though probably to a less extent, the Navy and the Mercantile Marine. The rapid expansion of material has overtaken the available resources in skilled personnel, capable of undertaking necessary maintenance work under active-service conditions. The possibility of some such *impasse* had not been overlooked in the Services, and extensive arrangements had been made, even before the war, to train artificers of various kinds and degrees of skill. Merchant Shipping, as usual trusted to fortune for a continued supply of seagoing engineers, and to the repairing yards for such overhauling as the engineers were unable to do at sea, or were prevented, by local restrictions, from doing in home ports. So far as the regular Services are concerned, however, it does not appear that the provision made was adequate to meet the problems entailed by the great expansion of mechanisation actually experienced in the course of the war and the strain that more active hostilities are likely to induce. The recommendations of Sir William Beveridge's Committee on Skilled Men in the Services, as put forward in their recent interim report, have thrown a somewhat unexpected light on the extent of their requirements in this direction. It would be unfair, however, to blame the Service departments for lack of foresight in not making still more extensive preliminary arrangements, for which neither public nor legislative opinion was properly prepared.

The Committee was appointed on June 9 to examine the use made of skilled men in the Royal Navy, the Army, and the Royal Air Force, and to advise whether the skilled manpower already at the disposal of these Services was being used with due economy and effect, whether the arrangements for training were adequate, and whether the demands for skilled recruits to Service trades, during the period ending on March 31, 1942, should be modified in any respect. They emphasise, in the interim report, that their inquiries are by no means complete, particularly in relation to the Navy; but offer such advice as they are able to give on the basis of the ground already covered, in view of the urgency of the question. The scope of the inquiry, they point out, involves such a wide investigation that it cannot be completed rapidly, yet it is likely to be of little use if not thoroughly carried out; but their conclusions show that, so far as the Army and Royal Air Force are concerned, a great deal of work has been accomplished in a comparatively short time.

Their conclusions are that the necessary work of modification, repair, maintenance and servicing of machines and instruments of war is now being

performed with "a notable economy" of skilled men, secured by a high degree of dilution, and extensive and well-designed arrangements for training. Vigorous efforts are being made within these Services to discover men, already enlisted but not engaged on such work, whose qualifications indicate their suitability for it; but, in view of the military programmes, a large increase of men for such work is inevitable, exceeding the numbers obtainable within the Services by training or transfer. They are satisfied, therefore, that there must be a further large withdrawal of skilled men from civilian employment, and a consequent increase in dilution in industry generally; and suggest that, of the anticipated requirements for the period from June 1 to December 31, 1941, 50 per cent. in the case of the Navy and Army, and 60 per cent. in the case of the Royal Air Force, should be entered by November 1, 1941, without prejudice to any further allocation that may be recommended in the report which it is hoped to present at the end of September. In conclusion, the Committee draw attention to the waste involved in retaining thousands of men of military age on clerical, storekeeping, and similar work which could be done by older men or by women. They realise that extensive plans have been prepared to substitute women for men in all suitable kinds of work and point out that, until these plans are realised, and so long as men of military age are used on work within the capacity of others, "the Government will not escape criticism for waste of manpower."

It is clear from the tenor of this report that a considerable overhaul of the industrial use of manpower is inevitable in the near future, and it may be expected that, on this subject, the trade unions will have something to say. Their attitude towards the Beveridge report as a whole has inclined to be critical, partly because neither the T.U.C. nor the British Employers' Confederation was represented on the Committee in spite of requests that they should be. A more solid ground for criticism, however, is the general feeling—not entirely without foundation—that the amount of what may be termed compulsory idle time is higher than circumstances warrant, and ought to be reduced without delay. The natural tendency is to blame "the management"—that convenient term for authority in general; a tendency for which justification can be found in some of the comments of the Select Committee on National Expenditure. In their Twenty-first Report, for example, the Select Committee make some very pointed remarks on the subject of deficiencies in management, and make the pertinent observation that "some of the worst cases of idling are found at factories where the contract is on the basis of cost plus a percentage." The implication is obvious, and might well be made the subject of a special *ad hoc* inquiry, for there is nothing more damaging to individual morale than enforced idleness, especially when it is coupled with a certain knowledge that there is suitable and useful work waiting to be done elsewhere.

For certain other of the alleged shortcomings of management, however, there is more excuse. Where delays are the result of lack of materials or of tools, the responsibility may not rest with the particular management at all, but with the Government department which controls the supply. We learned recently of a case in which machines, set up for a particular repetition job on brass ro l, were compelled to stand idle because of a delay of this kind; the rod required—the quantity ran into some miles—could not be supplied from stock, and the makers were quite unable to adjust their own plant for its production in the short time available between the placing of a new contract and the completion of the preceding order. In such a case, it is obviously unfair to blame the management of the works; and there are many other instances in which, although the management may be technically responsible, they can hardly be blamed in view of the fact that they also have been subjected to a high degree of dilution. The reserves of skilled managers, like those of skilled men, are not unlimited, and there is a real risk that the new demands for the Services may mean a reduced efficiency of industrial production which will offset, to some extent, the expansion of factories and equipment.

THE POLARITY OF LIGHTNING.

ELECTRICAL discharges in the atmosphere, of which lightning is the most spectacular form, are probably of more interest to engineers engaged in the maintenance and operation of transmission lines than to anyone else. The destructive effect of lightning is, however, the concern of everyone and the aggregate sum spent in attempts to eliminate, or minimise, damage to buildings must be very large. It has been estimated that at any given moment there are about ten thousand thunderstorms in operation in the world. These are so widely spread that consideration of their effects is not confined to any country, or any continent. As is generally known, thunderstorms are frequent and violent in the tropics, but actually in those regions discharges between clouds predominate and discharges to earth are relatively more common in temperate countries. As in many other meteorological matters, this country is fortunate regarding the incidence of thunderstorms, and in no part of it is one likely to meet the *hérissement* of lightning conductors on isolated farm houses which can be seen, for instance, in the Rhine Valley. A lightning conductor as ordinarily installed is no guarantee of complete protection. It should be bonded to all metal work and, indeed, to do the job properly, the whole building should be enclosed in a Faraday cage. This, or an approximation to it, would be a matter of heavy expense, and, as pointed out by Mr. B. L. Goodlet in a paper read before the Institution of Electrical Engineers in 1937, if all buildings were protected in this way, the cost would be much greater than that of lightning damage.

The Kelvin Lecture of 1929, by Sir George Simpson, was concerned with the subject of lightning, but since that time considerable progress has been made in the study of the phenomenon, Mr. Goodlet stating, in 1937, that "more knowledge of lightning has been gained in the last seven years than during the previous seventy." Mr. Goodlet's paper has, in turn, been added to by a further communication to the same institution. This, entitled "The Lightning Discharge," was published in the early months of this year. It takes the form of an official communication from the British Electrical and Allied Industries Research Association, and was compiled by Mr. C. E. R. Bruce and Mr. R. H. Golde.

The mechanism by which thunderclouds are electrified has been the subject of much discussion. Sir George Simpson has suggested that the separation of positive and negative charges, necessary for the process, is caused by the break-up of falling raindrops in an ascending air stream. The smaller drops formed in this way acquire a positive charge and the negative charge is carried away by the air. The largest water drop which can fall freely in air without breaking up has a diameter of about 0·5 cm. and a terminal velocity of 8 m. per second. Sir George postulates a vertical component of wind velocity, immediately below the storm centre, greater than this figure. Drops falling into this region from the upper parts of the cloud are broken into droplets with a positive charge. These are carried upward by the air stream, coalesce, fall again, are again broken up, and so on, the final result being an accumulation of positively-charged water drops in the storm centre, the upper portion of the cloud acquiring a negative charge. One result of this hypothesis is that lightning flashes should discharge positive electricity to the ground.

Professor C. T. R. Wilson has proposed an entirely different explanation. He assumes a charge, producing a downward-directed field, already existing inside the cloud. In such a field, positive ions would move down and negative ions move up. The only ions which can exist in a condensing cloud are large ions with a mobility of about 0·0003 cm. per second per volt per centimetre. Experiment has shown that the field intensity which will produce disruptive ionisation of air containing water drops of the size encountered in clouds is about 10,000 volts per centimetre. The velocity of the large ions in the cloud will, therefore, not exceed 3 cm. per second relative to the air. This is about the speed at which a water drop 0·1 mm. in diameter will fall through air under gravity. The result is that all water drops larger than this will descend faster than the positive ions. A water drop in a field of the direction assumed will have a negative charge induced on its upper surface and a positive one on its lower. The positive induced charge on the lower side will repel positive ions which are overtaken by the drop, but will attract negative ions rising up to meet it. If the drop is falling faster than the positive ions, no positive ion can reach it from above, in spite of the negative charge on its upper surface. In this way the larger drops can collect a negative charge, the corresponding positive charge being carried to the higher portions of the cloud by the upward air stream. The initial field which is postulated for this operation must be the normal field of the earth. This is directed downward as is required by the hypothesis. Recent work has shown that the majority of lightning charges to the ground are negative.

Data on this matter have been collected by Messrs. Bruce and Golde. They show that in the tropics the proportion of negative charges to positive is much larger than is the case in temperate regions. In observations on the polarity of flashes to earth carried out in South Africa, the ratio of negative to positive was 17 to 1. In similar observations in Great Britain, Germany, Italy and Sweden the average was about 3 to 1. This figure agrees with that obtained for the polarity of cloud charges which were carried out, by Simpson and Scrase, by means of balloon measurements at Kew. Mr. F. E. Lutkin, who has made oscillograph records at the Radio Research Station, suggests that the ratio of positive to negative field charges increases in the course of the day and is higher during the summer months than in autumn. This leads him to the conclusion that the majority of positive charges coincides with storms of the heat type, negative charges being more prominent in frontal storms. Messrs. Bruce and Golde do not agree with this and consider the relation between lightning polarity and meteorological conditions still undetermined.

It is possible that light may ultimately be thrown on this question by study of the relative meteorological conditions associated with tropical or temperate thunderstorms, the great difference in the proportion of negative discharges in the two types suggesting that temperature distribution plays a predominant part in the polarity developed. Thunderstorms which are frequent in the tropics are almost unknown in polar regions; they are commoner on land than at sea, in mountainous country than over plains, and are very rare over deserts. The absence of storms in polar regions is usually explained as being due to the dryness of the air and the impossibility of establishing the necessary vertical temperature gradient. Conditions are very different in the neighbourhood of mountains, which assist the formation of convection currents, while over land, as compared with water, the air under comparable conditions becomes hotter. These relative conditions may explain the distribution of thunderstorms throughout the world, but throw no light on the question of why negative or positive charges arise. Mr. Goodlet suggests that the process by which a charge is developed in a thundercloud is probably more complex than that advanced either by Simpson or Wilson. There are a number of rival theories. Some of these assert that a thundercloud produces lighting only after the formation of a cap of false cirrus cloud, which is a form associated with ice crystals, and that the formation of hail is an essential step in the process. C. Dauzère, in a paper presented at the High Tension Conference in Paris in 1931, postulated the positive electrification of cirrus crystals by photo-electric emission caused by ultra-violet rays from the sun, and Ross Gunn has regarded each water drop and its surrounding ionised water vapour as an electrical concentration cell. The equilibrium charge on each drop would be proportioned to its radius, and positive if the drop is evaporating and negative if it is condensing. Mr. Goodlet's comment is that all these rival theories result in the cloud base acquiring a negative charge, but it seems possible that if ultra-violet rays from the sun play an important part in the process the difference between temperate and tropical conditions may be understood.

NOTES.

THE RAILWAY AGREEMENT.

THE general basis of the financial agreement between the Government and the railway companies was made known last week. Full particulars will be laid before Parliament in due course, but there is no reason to suppose that these will modify the general position of affairs. The four main-line railway companies, in conjunction with the London Passenger Transport Board, are to receive a fixed annual payment of 43,000,000*l.* This will be divided, possibly with minor adjustments, as follows:—The Great Western, 6,669,000*l.*; the London and North Eastern, 10,148,000*l.*; the London Midland and Scottish, 14,736,000*l.*; the Southern, 6,607,000*l.*; and the London Passenger Transport Board, 4,840,000*l.* The figure of 43,000,000*l.* is exclusive of the net amount required for interest on capital issued or redeemed after the basic period of the original agreement between the Government and the railway companies. This corresponds to the end of 1937 in the case of the main-line companies, and to June, 1939, in the case of the Transport Board. It is also exclusive of the net revenue derived from investments in road-transport undertakings, and from investments in railways in Northern Ireland and Eire. The existing agreement, which will be replaced by this new one, provides a minimum guaranteed revenue of 40,000,000*l.*, independent of the extra revenue mentioned above, and contains the important provision that the companies will be relieved of the first 10,000,000*l.* of the cost of war damage. This latter matter is now to fall under the Bill dealing with war damage to public utilities. That Bill, which was promised many months ago, has not yet appeared, but it has been announced that its basis will be the shouldering of 50 per cent. of the cost of damage by the utility concerned. Whether the extra 3,000,000*l.* provided by the new agreement will cover this contingent liability it is impossible to say, and in any case, as far as the preliminary statement is concerned, it would appear that the companies will have to carry their own air-raid precaution charges. The companies will gain in that they will be relieved from the burden of any increased labour charges, and, as matters are moving at present, such increases may come. Even from this point of view, however, the companies cannot consider the matter with indifference. They will have to give thought to the conditions they will inherit after the war. It is stated that the agreement will continue for a minimum period of one year after the termination of hostilities. This is a rather indefinite expression. After the last war it was found necessary to fix a legal date to define the end of the war, which was long after "the termination of hostilities." Possibly this aspect of the matter will be more closely defined in the full particulars of the agreement. No information has been given to indicate whether the arrangement has been negotiated or imposed, but it does not appear that the railways are being treated too generously. The corresponding agreement in the last war was for 48,000,000*l.*

EXPENSES OF THE ELECTRICITY COMMISSIONERS.

The total expenses of the Electricity Commissioners for the financial year ending on March 31, 1942, have been approved by the Minister of War Transport at 919,800*l.* This figure shows a rise of 76,000*l.* as compared with that of the previous twelve months. In view of the increasing cost of most commodities and services, the rise is a moderate one and, actually, taken on the basis of the revenue obtained from the sale of electricity to consumers, a decrease is shown. The figure represents 17*s.* 11*d.* per 100*l.* of revenue, the corresponding figure of a year ago being 18*s.* The administrative expenses of the Commissioners included in the total also show a decrease, the sum being 48,700*l.* as compared with 49,800*l.* The item which has contributed most largely to the rise in the total is the payment made by the Commissioners to the Central Electricity Board to meet capital charges and other expenses defrayed by the Board in respect of civil defence measures. This payment is made under the provisions of the Civil Defence Act, 1939. The sum concerned is 93,600*l.*, compared with a figure of 48,400*l.* for the previous year. There will be no surprise that charges under this head should show an increase. The other item which goes to make up the total is interest and sinking fund charges in respect of money borrowed by the Central Electricity Board for the standardisation of frequency; the figure is 777,500*l.*, compared with 745,600*l.* for the previous twelve months. These charges fall on the Commissioners in accordance with the provisions of Section 9 of the Electricity (Supply) Act, 1926.

THE TRADES UNION CONGRESS.

The annual Trades Union Congress opened at the Assembly Hall, Edinburgh, on Monday, September 1, under the presidency of Mr. George Gibson. In his presidential address, Mr. Gibson made a strong appeal to all trade unionists to do their utmost to provide the weapons needed to destroy the enemies who menaced everything for which trade unionism had been struggling for 150 years. The Government should be given credit, he declared, for their many positive and far-reaching achievements. There was no lack of goodwill on the part of the trade-union movement in this country, but management, no less than labour, must do a good deal more to assist the production effort. Men and women who found themselves compelled to stand idle should be told of the difficulties that were responsible for the hold-up. In paying a warm tribute to the bravery and resolution of the Russian people and their fighting Forces, Mr. Gibson added that his remarks must not be taken to imply sympathy with the leaders of the British Communist Party, whose "astonishing gyrations" had placed them in the lowest category in the esteem of the British working class. Trade unions, he continued, had now become an integral part of the State; their status as such must be preserved and strengthened, and they must not be allowed to revert to any lower status after the war. At the present juncture it was not possible to lay down any hard and fast plan for the world after the war. For his own part, he saw no future for peace unless it could be based on a return to the ancient virtues of truth and love, of mutual help, of plain honest dealing between nation and nation as between man and man. The momentous joint declaration by the President of the United States and the Prime Minister seemed admirably to fit in with those general principles. The Congress then proceeded to discuss the General Council's report on women in industry, and some discussion ensued on the principle of "equal pay for equal work"; failure to observe which was alleged to be one of the main reasons why sufficient women had not been obtained for war-time industry by means of voluntary recruitment. It was contended that women were already enjoying, in some industries, basic rates of pay which were higher than those ruling in the engineering employment to which they were being compulsorily transferred. On the following day (Tuesday, September 2), the Congress concerned itself primarily with resolutions arising out of the co-operation of Great Britain with the United States and with Russia. An emergency resolution, submitted by the General Council, declaring the resolve of the British working classes to work for the extinction of the Nazi and Fascist regimes, welcoming the "Atlantic Charter," and pledging full aid to Russia, was carried unanimously. Included in the resolution, which was proposed by Sir Walter Citrine, the general secretary, was a suggestion that an Anglo-Russian Trade Union Council should be established, and that meetings should be held alternately in Russia and in Great Britain for the exchange of views. After Mr. C. R. Attlee, M.P. (Lord Privy Seal) had conveyed to the Congress a message of greeting from the Labour Party, a resolution was moved by Mr. N. Harrison (London General and Municipal Workers) urging the Government to regard the manning of industry as of not less importance than the provision of manpower for the fighting Services, and calling upon them to associate trade unions with the management of all vital industries. Mr. J. Hallsworth (General Council) addressed the Congress on the subject of the part of the trade unions in connection with the war effort. He referred particularly to the position of employees who, by the operation of the Registration for Employment Order, found that the assurance of reinstatement in their original employment applied only to those who were compulsorily transferred, and not to those who had already transferred to war work of their own volition. Mr. Hallsworth said that the General Council would ask the Minister of Labour to ensure that men and women undertaking essential work were given the same legal protection in this respect as was extended to those who had joined the Forces and the Civil Defence Services. He disclosed also that agreement had been reached on the terms of a Bill to restore pre-war practices in industry.

WATER PROBLEMS IN PENNSYLVANIA ANTHRACITE MINES.

According to a paper read by Mr. S. H. Ash, a district engineer in the Safety Division of the United States Bureau of Mines, before the Anthracite Section of the American Institution of Mining Engineers, the anthracite-mining region in Pennsylvania is now facing the same water problems which have been encountered for many years in parts of South Wales and which, more than two centuries ago, established the new industry of steam engineering in Cornwall. About 95 per cent. of the anthracite in the United States occurs in eastern Pennsylvania within an area of about 480 square miles which spreads across the drainage basins of the Susquehanna and Delaware rivers. At least a quarter of the known reserves have been worked out, for all practical purposes, and mining is now usually difficult. In recent years the annual output has been about 50 million tons, which is about half the figure reached during the peak years of the last war, when naval and other shipping requirements were at their maximum. Progressive flooding of the mines is seriously affecting the availability of the remaining reserves. The magnitude of the problem is illustrated by the fact that, during 1939, four large coal companies in the northern coalfield (Lackawanna and Luzerne Counties) pumped some 78,484 million gallons at heads ranging from 300 ft. to 1,200 ft. An estimate made in 1937 indicated that 33 tons of water were being pumped for every ton of anthracite produced. In one group of collieries, the quantity of water pumped per ton of coal increased from 19·5 tons in 1927 to 21·8 tons in 1931 and 29·3 tons in 1935. The annual cost of pumping is about 8 million dols., an average of about 16 cents a ton for the whole region. Mine water in the Eastern Middle field is drained largely through the Jeddo system of tunnels, which have a capacity of more than 150,000 gallons a minute. The original Jeddo tunnels were begun in 1891 and completed in 1894, but other connecting and auxiliary tunnels have been driven at different times, the most recent being brought into use in 1935. Water problems in the Western Middle field have led to the consideration of drainage tunnels as a possible solution in this area also, where the amount of water pumped, in 1935, had reached 72·2 per cent. of the total rainfall. Some relief has been afforded by re-aligning and regrading the Mahandy Creek, a work which was carried out by the Federal Government between 1933 and 1937. The position has also become acute in the Southern field, where the largest reserves of anthracite remain, but which also presents the most difficult mining conditions. General solutions of the problem, suggested by Mr. Ash, include the construction of flumes across breaks in stream beds; ditches to lead surface water to the streams; the diversion of streams to new and safer channels, and silting of existing channels to make them less pervious; re-afforestation and flood control by reservoirs and dikes; and the provision of additional pumping plants and drainage tunnels. The National Resources Committee, reporting to President Roosevelt in 1937, held that the Federal Government should take no action in the matter until the State of Pennsylvania had first exhausted its own remedies; but the evidence submitted at various conferences indicated, according to Mr. Ash, that there was urgent need to co-ordinate the efforts of State and Federal agencies, as well as those of the individuals and firms concerned, and to investigate the problem for the region as a whole. A sound engineering solution was imperative.

SOME ASPECTS OF THE WAR AT SEA.

By ADMIRAL SIR HERBERT RICHMOND, K.C.B.

Two years have now elapsed since the declaration of war on September 3, 1939. A brief survey of some aspects of the war at sea may be allowable, together with such tentative deductions as our limited extent of knowledge renders permissible. In the first place, it must be remembered that Great Britain began the war under a severe handicap. Owing to the naval treaties to which she had subscribed, her strength at sea was inadequate to the needs of her defence. The Washington Treaty had imposed fetters upon her freedom to construct the vessels to meet the needs created by circumstances. By an arbitrary and wholly unscientific assumption, vessels of above 10,000 tons and carrying armaments of over 8-in. calibre were classed as "battleships," and Britain's total "battleship" tonnage was limited to 525,000 tons. The Versailles Treaty had limited the armoured ships of Germany to 10,000 tons each, and when Germany translated some of that tonnage into the form of three powerful armoured cruisers, armed with 11-in. guns and with a speed of 26 knots, Great Britain found herself estopped from answering this new type of commerce raider in the way in which similar moves had been answered in the past, that is, by the building of corresponding ships; for any tonnage so used would have had to be deducted from her battleship quota and would have reduced the dangerously low number (15) of her capital ships. Britain's naval building must always be a long-term policy; it cannot be framed solely in the light of an existing situation and the possibilities of war with one particular Power, however great those possibilities may appear. Friendships and antagonisms are transitory and the ally of one decade may be the enemy of the succeeding one, as we have often found and are again finding to-day. As, therefore, the Treaty permitted the building of ships of the greatest size agreed upon—35,000 tons—by other Powers, Britain was obliged to furnish herself with ships capable of meeting them, both in size and numbers. She could not, therefore, provide the armoured cruisers needed to deal with the so-called "pocket battleships."

The London Treaty, a still worse-considered engagement, effected a further weakening of British defence. In stark defiance of all the lessons of three centuries of sea warfare, the Government of that day—and, it must be added, Parliament—accepted an arrangement by which Britain's cruiser and destroyer strength was to be governed by the cruiser and submarine forces of other Powers, instead of by the duties which these classes of vessels are needed to perform. This was an egregious error. It flew in the face of experience. It had been definitely rejected by previous administrations, including the most recent. Nevertheless, the Government of 1929 committed the country to a quota of 50 cruisers, the number desired by, and considered sufficient for, the United States, a country whose needs differ profoundly from those of the British Empire; and to a flotilla tonnage which, at the most, could furnish about 150 destroyers of a comparatively small size. In the war that had so recently ended, the flotilla forces of the Allies numbered some 700, of which over 400 were British, and all these, together with some 120 cruisers, were needed to preserve the country from starvation.

Germany was naturally well aware of Britain's weakness, and German naval strategists set themselves to think out a form of warfare suitable to the prospective situation and the new instruments. Accepting the basic principle that the ultimate aim in naval war is the control of sea communications, and that it was upon trade by sea that Great Britain and France depended for their existence, and that in the trade routes lay their most vulnerable spot, Germany resurrected the theory of the *guerre de course*, as it had been promulgated by Louis XIV and his ministers. It was an error to devote the country's efforts to obtaining "command" by concentrations of force and pitched battle of the massed strength; this indirect method of destroying the commerce that supplies the needs of Britain should be replaced by the direct method of attack upon the shipping itself. Modern construction provided the instruments, the submarine, the heavy cruiser and the mine. Aircraft do not appear to have been allowed for in the German calculations, possibly because it could not be foreseen that so rapid a collapse of France would be brought about, to furnish bases on the coast from which these then comparatively short-ranged instruments could strike at the trade routes; though in Italy much was hoped for, since Italian aircraft could reach the trade route in the narrow Mediterranean with ease.

The treaties, already referred to, had hamstrung the British Navy. Its numbers would be too few to give the protection that had been given in 1917-18, and, though the agreement had been signed by which submarines were to observe the same conduct as surface vessels, and this limitation of their powers reduced them to the level of somewhat ineffective surface craft, nothing would be easier than to throw those limitations overboard whenever it suited the German command. Convoy would be forced upon Britain both by the submarine and the cruiser forces, and the new heavy cruiser would be a factor of great importance. The new type combined great endurance with an armament of 11-in. guns and a certain degree of armour protection, and thus could range the ocean with complete security—the ideal propounded by the French when they designed the Dupuy de Lôme in the late 'eighties. In an article in the *Militär Wochenblatt*, written in 1939, Admiral Meurer outlined the policy of the new school of German naval thought. The presence of these powerful vessels and of the heavy 10,000-ton regular "Washington" cruiser on the trade routes would force the adoption of convoy, and escorts of the types that sufficed in the last war, composed of the older cruisers and armed merchantmen, would be insufficient. The great majority of the 50 British cruisers were armed with 6-in. guns—only 15 were 8-in. gun ships—and, against heavy cruisers with 8-in. guns and even less against armoured ships of the Deutschland type, such escort cruisers would not be of any great avail; if such dangers as attack by heavy and armoured cruisers were to be faced, older battleships would be needed, as was the case in the Norwegian convoys in 1918. But older battleships no longer existed—they had been scrapped at Washington; and of battle-cruisers, the only heavy ships capable of overhauling the Deutschlands, France and Britain combined could muster no more than five, a number wholly inadequate to furnish escorts to all the numerous convoys that would be needed to sustain the life and efforts of the Allies.

The prospects of crippling this country thus appeared respectable, even though Germany possessed no battle fleet. Accordingly, when the decision was taken to attack Poland as the first step towards the domination of the whole of Europe, preparations were made for a simultaneous attack on the trade of the Allies in case they should venture on opposition. The existing German submarines, not then very numerous, were sent out in advance to predetermined positions on the approach routes to Britain, and at or about the same time one of the armoured cruisers, the Graf Spee, was dispatched into the South Atlantic, where she sank the s.s. Clement on September 30. So the campaign at sea began.

The opening submarine attack was costly to Britain. In the first month the submarine sank over 187,000 tons of British, Allied and neutral shipping, of which 155,000 tons were British. In the following months the tale of neutral losses increased, reaching close upon 100,000 tons in January, 1940. One prominent feature of the war has been the way in which the neutral has been treated by the Germans; out of 7 million tons of shipping sunk by them up to the end of June, 1941, one-seventh was neutral, much of it engaged on voyages unrelated to the war or to Britain. But the convoy organisation was set into operation with most commendable speed and was used by both British and neutral vessels. Still, a great deal of shipping, particularly of the faster types, continued to sail unescorted. By the end of May, 1940, when France had surrendered, 572,000 tons of neutral ships had been illegally sunk. Germany has, in fact, deliberately thrown aside every obligation of established international law and of the agreements into which she had voluntarily entered, allowing the neutral none of his historic rights; and, as the neutrals have not attempted to assert these rights or to insist upon them in any way, law has gone by the board. Even the most powerful among them, the United States, although such a staunch upholder of neutral rights in the last war, has done nothing in this direction. By forbidding her shipping to enter the war zones, she was able to steer clear of "incidents."

In war there is only one check upon breaches of the law of nations, apart, that is to say, from any retaliatory action which belligerents may choose to take in their own interests, and that is intervention by the Powers not at war. "Violations of international law," said Mr. Elihu Root, in 1916, "must be treated as violations of the rights of all, for the law which has been broken is the law of all"; but the neutral policeman has held his hand, and half a million tons of neutral shipping lies at the bottom of the sea as the result.

The invasion of Norway, the primary object of which was to obtain naval and air bases outside the "wet triangle" of the Heligoland Bight, the need for which had been asserted by German Admirals before the war, took place in April, 1940. The unready and unsuspecting people of Norway succumbed to an attack prepared in the dark and assisted by traitors within the country. At first sight it had the appearance of being a most hazardous adventure, an invasion of an oversea territory without command of the sea. That assumption failed to take account of the power of the submarine and of aircraft, working from bases in close proximity to the objective area. The British surface forces, operating from the other side of the North Sea at a distance of 600 miles, could not be kept in continuous position in the Skagerrak, nor could they have the support of aircraft; and the waters were strewn with enemy mines. In these circumstances it was the enemy who, undeterred by the prospect of some fairly high losses, had a sufficient command of the sea to move his transports.

We have to realise that the "command of the sea" is now no longer a matter in which surface or even submarine vessels are alone concerned. He who possesses an instrument which can sink merchant ships, whether it be a battery of guns on land or flights of bombers in the air, commands the sea within the ranges of those instruments, as the Turks "command" the Dardanelles and the Germans, with their aircraft established in Greece and the Ionian Islands, command the waters in those parts. It is true that, if Britain had possessed a larger number of flotilla craft, more might have been done against the enemy surface transports in the Skagerrak; but these were not available, for the demands of the protection of trade to the westward, and in the North Sea and the Channel, were absorbing the services of all there were. British submarines took a toll of the transports, but the losses were not sufficient to stop the movement of the large number of troops the enemy was prepared to send into Norway. Throughout the subsequent campaign in that country, the British lacked air support on land and at sea, owing to the fact that the available bases all fell into the enemy's hands. The success of the German operations was a strong reminder of the perennial doctrine of the "liaison of arms."

The over-running of Belgium, Holland and France brought the enemy the vast advantage of the possession of all the ports on the west of Europe from Narvik to the Pyrenees; and it brought him also an ally, Italy. Mussolini, convinced that a German invasion of England would follow at once, and would succeed, calculated that the moment had come when he could safely fly to the help of the victor and gather his share of the loot that would be going; indeed, if he was to get his share he must make an appearance quickly in order to establish his claims as a confederate. As the end would come quickly, it did not appear to matter that Italy was dependent to the extent of between 75 per cent. and

98 per cent. of her cotton, wool, iron and oil upon imports which must be brought by sea: existing stocks would see her through, for, unfortunately, the British Government, in the hope that Italy would remain neutral if kindly treated, had allowed a flood of these and other materials to enter the country. Nine months earlier, Italian storehouses were almost bare; now they were replenished sufficiently to serve through the short war that appeared to lie ahead. Thus at one stroke Britain was deprived of one ally and faced by an additional enemy; an enemy with a respectable fleet, a strong air force, and an army in Africa greatly superior to her own in every respect. The situation was critical.

The Italian conception of war in the Mediterranean was based on the calculation that, in those narrow waters, aircraft, submarines, and very fast light craft in large numbers would so weaken the British battle forces that the Italian heavy ships, already more numerous than the British, would be able to take the risk of fighting them. Malta, lying a bare 60 miles from Sicily, would be untenable, and the Sicilian Channel would be a safe line of passage for still further reinforcements to reach the army in Africa. Motor transport would overcome the difficulties of the desert approach to Egypt, and the Italian army would occupy that country and drive the British fleet from Alexandria and Haifa, when, being without any base in the Eastern Mediterranean, it would have to abandon the Levant. Spanish gratitude for help in the Civil War might perhaps be counted upon to come into play when success had been reached in the east, and Gibraltar would be captured or rendered useless. All the possibilities of a blockade of Italy would thus disappear. The picture may well have seemed rosy in Rome at that moment.

The hostility of the Duce had been so clearly shown before he dragged his unwilling countrymen into the war against England that the precautionary measure had been taken of routing the Mediterranean trade round the Cape. The fleet was thereby relieved of the burden of defending the Straits trade and could devote its attention and efforts to the military campaign and to those sea communications which served the needs of the Army, the fleet and the garrisons at the bases. Aircraft were soon to demonstrate both their power and their limitations in all the operations at sea and on land. They inflicted shipping losses on both sides; but they did not prevent or appreciably hinder the British heavy and lesser ships from bombarding the enemy's positions and armies on the African coast, supplying General Wavell's army in its advance to Benghazi, and maintaining the garrison of Tobruk when it became an isolated outpost of Egypt.

The Italian invasion of Greece gave Britain the opportunity to improve her position as regards bases. Crete was occupied, and thereby the fleet was better placed for attacking the Italian fleet in its ports, damaging the harbour facilities and rail communications in Italy, and harassing the transports in the Sicilian Channel than it had been when based only on Alexandria. The importance of Crete did not lie only in the increased powers of attack that it conferred; there was also a defensive value in preventing the enemy from having the use of the island and so keeping his aircraft at a greater distance from the scenes of the operations on the coasts of Africa and Palestine. It is difficult not to feel that, either these advantages and the dependence of the whole of the war in the Mediterranean on the command of the sea were insufficiently appreciated, or the possibilities of the recapture of Crete by the enemy were underestimated; for, otherwise, it would seem obvious that every possible measure necessary for, or contributory to, its defence would have been taken during the seven months that elapsed between its occupation and the enemy's attack. A shortage of anti-aircraft artillery, resulting from the heavy demands in other areas, was given as the reason for not having established stronger defences in Crete: but it is hard to believe that, if the importance of Crete and the transporting capabilities of aircraft had been realised, guns could not have been spared for some less vital spot.

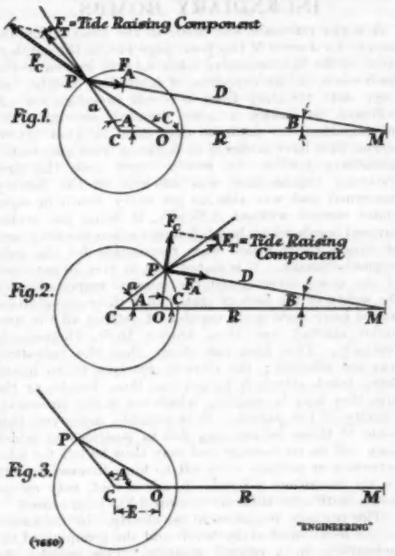
(To be continued.)

LETTER TO THE EDITOR.

THE TIDE-GENERATING FORCES.

TO THE EDITOR OF ENGINEERING.

SIR,—The letter signed W. J. T., published in your issue of February 21, 1941, on page 154, speaks for the engineer who has endeavoured to obtain a rational conception of tide-raising forces. There are many such. The article by Dr. A. T. Doodson, in your issue of May 23, 1941, page 414, is a scholarly presentation of the subject, that is almost, but not entirely, satisfying to the engineer who is accustomed to dealing with forces and their reactions. As stated by Dr. Doodson, the tide-generating force is the tractive, or horizontal, component of forces acting on a particle of water at the earth's surface. Obviously the earth's gravity and centrifugal force due to rotation about its own axis, act in a vertical direction and have no such horizontal components. On the other hand, the moon's gravitational attraction and centrifugal force due to the rotation of the particle about the earth-moon centre of gravity axis have appreciable horizontal components. These vary in magnitude with the position angle of the particle relative to a plane through the centres of the earth and moon. Similar horizontal components exist due to the gravitational



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attraction of the sun on the particle of water, but these are considerably smaller in magnitude than those due to the lunar attraction. The actual tide-raising force will be the vector sum of all such horizontal components, and this acts on the particle of water to cause a tidal flow in accordance with the principles of inertia and fluid mechanics.

In the accompanying diagram, Fig. 1, drawn in the equatorial plane of the earth and with the moon's centre assumed to be in this plane, we have: C = centre of the earth, M = centre of the moon, O = centre of gravity of the earth and moon, P = a particle of water on the earth's surface, A = position angle of particle P, measured at earth's centre, B = position angle of particle P, measured at moon's centre, C = position angle of particle P, measured at centre of gravity axis, a = radius of the earth, R = distance of the moon from the earth, and D = distance of particle P from the moon.

The centrifugal force F_C acting on the particle P is proportional to its distance from the axis of rotation O, which is the radius O P. The moon's attraction force F_A acting on the particle P is inversely proportional to the square of its distance from the moon, which is D in the figure. These are two real forces which combine to give the resultant force F, making an angle with the vertical to the earth's surface C P. The horizontal component of F, F_T, is the tide-raising force acting on the particle P. Thus we have a real force F_T, which in magnitude and direction explains the tidal flow, causing a high tide to occur on the side of the earth away from the moon. In an exactly similar manner the forces acting on a particle in a position towards the moon, will cause a tidal flow and a high tide to occur on the side of the earth facing towards the moon (Fig. 2).

In order to clarify the quantitative understanding of this tide-generating force consider the relations shown in Fig. 3. The forces acting on a particle C at the earth's centre are the centrifugal force due to rotation about the centre of gravity axis O, and the moon's gravitational attraction. The equilibrium of the earth-moon system is established by these two forces, which are equal and opposite in direction. The centrifugal force on C is proportional to the radius O C and the gravitational attraction of the moon is inversely proportional to the square of the distance R. These forces can be represented by the vector quantity C O equal to $\pm$ E. Likewise the vector O P represents the centrifugal force acting on the particle P located at the position angle A. Now it will be noted that the vector sum of C O and O P is C P, having the direction of the earth's radius to P, that is the resultant of these two forces is vertical to the earth's surface at P. Thus, if the particle P were subjected to the combined centrifugal force O P and a gravitational attraction O C exactly equal to that acting at the centre of the earth there would be no horizontal, or tide-raising, component to the resultant force on P. However, this is by no means the case, and we know that the gravitational attraction at P differs from that at C in both direction and magnitude. When the particle P is located farther from the moon than the earth's centre, as in Fig. 1, the gravitational attraction on P is less in magnitude than E, and when nearer to the moon, Fig. 2, the gravitational attraction is greater. Because of this variation in the moon's attractive force, according to the location on the earth's surface, we have a horizontal component to the resultant force, which operates to cause the tidal flow.

It is believed that this conception of the problem affords an entirely adequate explanation of tidal action and it is noted with satisfaction that the quantitative results are entirely consistent with Dr. Doodson's conclusions. However, we believe that the reasoning pursued may be more acceptable from a purely engineering viewpoint. The derivation is given below.

Yours faithfully,

J. S. TAWRESEY.

S.K.F. Industries, Inc.,
Philadelphia, Pa., U.S.A.
August 6, 1941.

The derivation of the value of the horizontal or tide-raising component due to the centrifugal force and the gravitational attraction acting on particle P is as follows:—

Centrifugal component $F_{TC} = F_C \sin (C - A)$ and as

$$\frac{F_C}{E} = \frac{\sin A}{\sin (C - A)}$$

$$F_{TC} = E \sin A.$$

Gravitational component $F_{TA} = F_A \sin (180 - (A + B))$ and as

$$\frac{F_A}{E} = \frac{R^2}{D^2}$$

$$F_{TA} = E \frac{R^2}{D^2} \sin (A + B).$$

Also, since

$$\frac{\sin (A + B)}{\sin A} = \frac{R}{D}$$

$$F_{TA} = \frac{E R^2}{D^2} \sin A.$$

Hence the resultant tide-raising component is

$$F_T = F_{TC} - F_{TA}$$

$$= E \sin A \left(1 - \frac{R^2}{D^2}\right)$$

$$= E \sin A \left\{1 - \left(\frac{1}{\frac{a^2 + R^2 - 2\,a\,R \cos A}{R}}\right)^{\frac{3}{2}}\right\}$$

since $D^2 = a^2 + R^2 - 2\,a\,R \cos A$,

$$= E \sin A \left\{ 1 - \left(\frac{1}{1 - \frac{2a \cos A}{R}} \right) \right\}^{\frac{1}{2}}$$

$$= E \sin A \left(1 - 1 + \frac{3a \cos A}{R} \ldots . \right).$$

Neglecting terms involving $\frac{a^2}{R^2}$ and higher powers

$$F_T = \frac{3a E}{2R} \sin 2A$$

and since

$$E = \frac{M_M a^2 g}{M_E R^3}$$

where

M_M = mass of the moon,
M_E = mass of the earth, and
g = acceleration of gravity,

$$F_T = \frac{3}{2} g \frac{M_M a^2}{M_E R^3} \sin 2A.$$

This is exactly equivalent to the force as previously derived by Dr. Doodson.

OBITUARY.

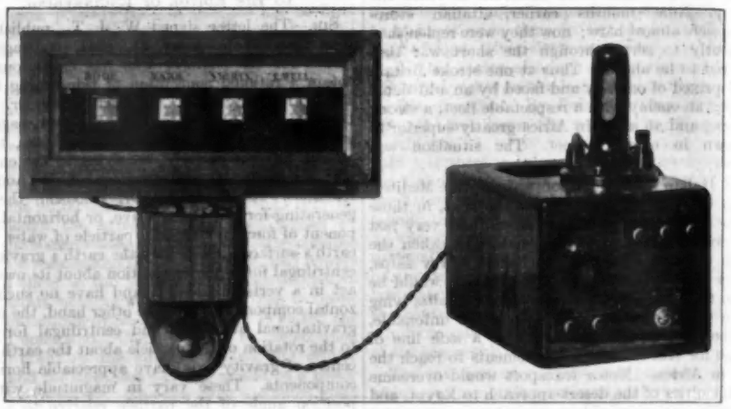
BRIG.-GEN. C. H. MITCHELL.

NEWS of the death, in Toronto on August 26, of Brigadier-General Charles Hamilton Mitchell, C.B., C.M.G., D.S.O., has been received in London. General Mitchell, who was well known in Canada and in this country as a consulting engineer on hydro-electric works and as Dean of the Faculty of Applied Science and Engineering in the University of Toronto, was the son of the Rev. G. A. Mitchell, B.A., and was born on February 18, 1872. From 1888 until 1892 he attended the School of Practical Science, University of Toronto, and was awarded the degree of B.A.Sc., and that of C.E. after serving a further post-graduate year. During his long vacations he underwent training in civil engineering, serving first as assistant to Mr. P. K. Hyndman and afterwards under Mr. E. ?. Burns, city engineer, Niagara Falls, New York. In the summer of 1891, he was engaged, under Mr. Hyndman, on surveys and the drawing up of plans for a railway, 25 miles in length, from Inverness to Victoria, on Cape Breton Island. In the two succeeding years, as assistant to Mr. Burns, he was employed on the design and construction of public works, mainly sewers and waterworks. On leaving the University in 1894 he started a private practice at Niagara Falls, Canada, and was also engaged as town engineer on municipal work, chiefly hydraulic engineering. He prepared general and detailed designs and specifications for the Niagara Falls sewerage system and for hydro-electric stations on the Fenelon Falls and elsewhere in Ontario.

In 1902, General Mitchell was appointed assistant engineer to the Ontario Power Company, Niagara Falls, and until February, 1904, was in charge of field work. In March, 1904, he superintended the mechanical department and in 1906 was made consulting engineer to the Company. In 1911 he was appointed consulting engineer to the Government of Canada and was engaged subsequently on many projects for the development of water power and the conservation of water in various parts of the Dominion. In 1924 he was appointed a Canadian Government representative on the St. Lawrence Waterway project. In 1922 he served as President of the Professional Engineers' Association, Ontario; from 1927 until 1933, as president of the Toronto Board of Trade, and in 1929 as president of the Engineering Institute of Canada. General Mitchell was elected an associate member of the Institution of Civil Engineers in 1906 and was transferred to the class of member in 1912. He was also for many years a member of the Engineering Institute of Canada and of the American Society of Civil Engineers. He had been an officer in the Canadian Militia since 1899 and served in the war of 1914-19 as General Staff Officer (Intelligence) with the 1st Canadian Division at the G.H.Q. of the British Forces in Italy, and finally at the War Office in London. He was mentioned in dispatches seven times and was awarded the D.S.O. in 1916, the C.M.G. in 1917, and the C.B. in 1918. He also received French, Belgian and Italian decorations.

INCENDIARY-BOMB DETECTOR.

MESSRS. MORTIMER, GALL AND COMPANY, LIMITED, LONDON.



THE AUTOMATIC DETECTION OF INCENDIARY BOMBS.

A BRIEF reference was made in the issue of ENGINEERING for June 6 of this year, page 448, to the employment of the light-sensitive selenium cell, known as the Radiovisor, in the detection of incendiary bombs, but some data resulting from a recent investigation are sufficient to justify a more detailed account. The investigation was made to determine to what extent serious fires have occurred in factories from undetected incendiary bombs. In nearly every case the fire-watching organisation was efficient in the factory concerned and was able to get every bomb in sight under control without difficulty, it being the undiscovered bombs which had fallen on roofs or in such places as closed yards which were responsible for the subsequent damage. It is stated that in over 70 per cent. of the cases investigated the persons responsible for the safety of the factory stated that their organisation would have been quite capable of getting all the fires under control had they known their whereabouts precisely. This does not imply that the patrolling was not efficient; the obvious reaction to an incendiary bomb attack is to put out those bombs, or the fires they may be starting, which are in the immediate vicinity of the patrols. It is possible, moreover, that some of these bombs may fall in positions in which they will do no damage and may thus be left for later attention or perhaps even left to burn themselves out. In the meantime a bomb on, say a roof, may escape notice until a fire difficult to control has been caused.

The primary requirement is, clearly, the indication of the location of every bomb and the grouping of the indications in a central position. This enables the persons in charge at the central position to send fire-fighting squads to the exact spot at which the bomb has fallen and, if the attack is heavy, to distribute these squads to the positions involving a heavy fire-risk; first, for example, to paint stores, pattern shops and woodworking shops, that is, assuming the personnel is not sufficient to deal with all the fires at once. The bombs which fall in localities involving little fire risk, such as yards, brick buildings containing stored metal and the like, should there be a shortage of personnel, may be dealt with subsequently. The locating of all bomb sites should be accompanied by means for discrimination, should such discrimination be necessary. The system of detection by the selenium cell referred to in our previous note would seem to meet these requirements. It has, indeed, proved effective in factories in which it has already been installed. This system has been developed, as indicated in the previous note, by Messrs. Mortimer, Gall and Company, Limited, 115–117, Cannon-street, London, E.C.4.

From the nature of the system it is not practicable to illustrate the apparatus employed as it is actually fitted, but the accompanying illustration, which is of a demonstration set only, will serve to show the units. In this illustration a selenium detector bridge is shown seated on top of the case containing the electrical gear, while to the left of it is a warning bell and an oscillating disc detector. In practice, the selenium detectors are installed in the works in positions which appear to be most suitable. Each detector will cover an area ranging from 8,000 sq. ft. to 10,000 sq. ft. of open workshop. Usually some are installed inside and some outside. A common and effective position for the outside detectors is on the ridges of the saw-tooth or north-light roof often adopted for shops of considerable area. A detector is not needed on every ridge, but on alternate ones only, as the valleys of the ridge without a detector are effectively covered by the detectors on the ridges on each side of it. The valleys of such roofs are particularly dangerous spots, since the roof purlins, when of wood, are easily ignited from bombs. The gutters into which a bomb might roll are best protected by a covering of expanded metal. The detectors are easily attached and on some sites on roofs are protected by a small canopy so that they will not respond to, say, a gunflash and so give a false alarm.

There is a set of electrical apparatus for each selenium detector, the wiring between the two usually carrying current at 50 volts. The supply to the apparatus may be at 100 volts, 200 volts, or 250 volts, and may be either alternating current or direct current. The terminals to which the detector is connected are seen at the bottom left-hand corner of the case. Above them is a sensitivity control knob, and to the right a re-set switch. The other terminals are for the bell and indicator leads. An earthing terminal is provided. The electrical apparatus includes transformers. The current for the detector has already been mentioned; that for the bell and indicator circuit is supplied from an independent battery and varies from 4 volts to 24 volts, according to the lay-out. The electrical cases can be arranged in groups of three or four in any convenient place in the shops. The indicator panel and alarm bell are situated in the room of the works A.R.P. controller. Each dial of the indicator is labelled in accordance with the position of the detector actuating it, and the panels have generally a much larger number of windows than the demonstration set shown.

In the event of a number of incendiary bombs falling on a works, more than one of the detectors will most probably be actuated, when the warning bell will ring and the discs in the appropriate windows of the indicator will oscillate to show near which detector stations the bombs are lying. The vulnerability of the sections concerned can be immediately assessed and the fire-parties allocated accordingly. The allocation of men is, of course, a matter for the works concerned, but it may be of interest to cite an example in a works in which the selenium-cell detection system is fitted. In this works the controller is provided with a tabulated list of departments showing the minimum number of men that should be dispatched to that department in case an incendiary bomb should fall in it. The actual list is in the following form: pattern shop, 3 men; paint shop, 4 men; office block (west), 6 men; office block (east), 4 men; loading bank, 1 man, and so on. The problem of the undiscovered delayed-action incendiary bomb is also solved by the system above described.

An interesting development concerns the security of special offices and rooms to which access is permissible in cases of emergency only. This consists of a box attached to the door of the room and having a slot into which the door key is dropped when the door has been locked. The key remains inaccessible, but when normal access is required it can be caused to fall out into a tray at the front of the box by the operation of a switch in the control room. In an emergency, as when incendiary bombs fall, it is delivered automatically, since the actuating mechanism is connected with the detector system.

LABOUR NOTES.

THE allegations in the Twentieth Report of the Select Committee on National Expenditure, referred to in the leading article on page 171, *ante*—namely, that a certain district delegate in a ship-repairing centre was impeding output by fining men who worked overtime without his permission and by placing obstacles in the way of the use of pneumatic tools—are understood to have been discussed at a private meeting of the United Society of Boilermakers and Iron and Steel Shipbuilders at Edinburgh on August 27. A statement was subsequently issued by Mr. Mark Hodgson, the general secretary of the union, in which he admitted that there had been some difficulty in connection with the introduction of pneumatic riveters in one district. The men there were not in favour of the tools, not being convinced that their use would increase output, and he believed that the employers shared that opinion to a considerable extent.

The Ministry of Labour and National Service brought pressure to bear (the statement continued) and a conference was held which resulted in an agreement, since put into effect; so that any causes of criticism that might have existed had been removed. The Select Committee's report, therefore, was out of date. With reference to the assertion that a district delegate had been fining union members, it was pointed out that no district delegate had authority to impose fines nor the machinery to undertake any such action. All districts were working harmoniously in the national war effort, emulating the example set by the Society itself, through its officials.

Speaking at Princes Risborough last week after the formal handing over of a hostel for agricultural workers, Mr. R. S. Hudson, the Minister of Agriculture, called on Mr. Bevin to provide him with 10,000 more men for land work. When, he continued, he asked for increased production, every war agricultural committee in the county told him that the first requisite was a supply of additional labour, and one of the main obstacles to the supply of additional labour was lack of accommodation. "My problem," Mr. Hudson said, "was whether I should provide the accommodation or the men first. I came to the conclusion that we must tackle both problems together. This morning I have got the first hostel. This afternoon I am going back to Mr. Bevin to ask him for the men to put in it. As each hostel is ready, I propose to go to Mr. Bevin and say 'Produce the men.'"

It is stated that large numbers of ex-miners, now in other employments, are to be directed by the Ministry of Labour and National Service to return to the pits. Although volunteers, following the registration of ex-miners, totalled about 25,000—the number the Government decided to recruit to the industry—only a proportion of them, it has been found, can be released. Many of the men are now in key positions in the war industry and cannot be released. As a result of discussions between the President of the Board of Trade and the Coal Production Council, measures are to be taken to speed up the return of men to the pits. The Ministry of Labour's powers of direction are to be exercised as a matter of urgency.

The report of the General Federation of Trade Unions for the second quarter of the current year states that the number of affiliated societies is 90. Of these, 54 are on the higher scale, 34 on the lower scale and 2 on both scales. The membership of the affiliated societies on which contributions are paid is 266,177, of which 155,533 members are on the higher scale, 104,926 on the lower scale and 5,718 on both scales. The gross membership is 316,347. During the three months 5,255*l.* 9*s.* 3*d.* was received in contributions and 332*l.* 8*s.* 4*d.* paid out in benefits.

Discussing the industrial problems which are likely to emerge when the war comes to an end, Mr. Bell, the general secretary of the General Federation, expresses the opinion that they will be "many and complex." A new approach to them will, he believes, be necessary as the world will have become impoverished. "An essential condition," he goes on to say, "of the relationship between capital and labour must be a willingness to settle all differences and to correct mistakes speedily. In these anxious days the country cannot afford to waste time and material. Everything is secondary to the war effort. Agreements to negotiate in order to affect the settlement of disputes are the present order of the day. This system may, or may not, continue to operate successfully. But if history is allowed to repeat itself, those trade unions which have made reasonable financial provision to sustain them during trade difficulties which may arise after the war will have planned wisely and in the best interests of their members."

On the invitation of the council of the American Office of Production Management, a mission representing management and labour in British industry is to begin a tour of the defence industries in the United States this month. The management representatives on the mission are Mr. F. C. Braby, managing director of Messrs. Frederick Braby and Company, Limited, Mr. C. K. F. Hague, director of Messrs. Babcock and Wilcox, Limited, Mr. C. P. Lister, chairman and managing director, Messrs. R. A. Lister and Company, Limited, and Mr. J. S. Turner, managing director, Moira Colliery, Limited. The Labour representatives are:—Mr. A. A. H. Findlay, United Patternmakers' Association; Mr. G. A. Isaacs, M.P., National Society of Operative Printers and Assistants; Mr. J. Kaylor, Amalgamated Engineering Union, and Mr. W. Lawther, Mineworkers' Federation of Great Britain.

Under an award of the Industrial Court issued last week, patternmakers and fitters, employed at time rate in the workshops of the four main line railway companies, are to receive an increase in wages of 1*s.* a week. The increase is to take effect as from August 21.

The claim of the Amalgamated Engineering Union for an increase of wages was supported by representatives of the organisation—with whom were representatives of the National Union of Foundry Workers—at a conference, in London on Wednesday last week, with the Engineering and Allied Employers' National Federation. The meeting was adjourned in order to give the employers an opportunity to consult their associations. The claim is understood to be based on the following resolution which was adopted unanimously by the National Committee at its recent meeting:—"That this National Committee records its disgust at the inadequate award made by the Arbitration Court, and instructs the Executive Council to make application for an advance of 4*d.* per hour on the present basic rates, any advance so granted to be paid from date of application. Failing a satisfactory settlement by September 1, the National Committee be recalled forthwith to decide the policy to be adopted."

Earlier in the week, representatives of the Transport and General Workers' Union and the National Union of Municipal and General Workers submitted to the Engineering and Allied Employers' National Federation arguments in support of an application for an increase in the wages paid to women employed in engineering. A wage increase of 9*s.* per week on basic rates was claimed for adults with a proportionate advance for women under 21 years of age. The ultimate aim of the union is to obtain for women "equal pay for equal work." This conference was also adjourned in order to give the employers an opportunity to examine the arguments submitted.

Women are not eligible for membership of the Amalgamated Engineering Union. At its meeting this year, however, the National Committee unanimously adopted the following resolution on the subject of the wages paid to women in the engineering industry:—"That the National Committee expresses concern at the Government's decision to register and mobilise the women of the country for use in the engineering factories, as under the existing wage scales and conditions of employment of women in the engineering industry, it is shown that this policy is for the purpose of cheapening production in the labour costs. The National Committee instruct the Executive Council in conjunction with the other unions concerned, to open up immediately negotiations with the Engineering and Allied Employers National Federation for the amendment of the agreement dated May 22, 1940, so that the qualifying periods shall be considerably reduced and the principle of equal pay for equal work definitely established."

In a new list of reserved schedule changes, architectural assistants (with five years' experience) are reserved at 35. This is a new reservation and is not retrospective. Stockkeepers and storekeepers in "unprotected" establishments who have been reserved to 35 are de-reserved immediately. The reservation age in the nut and bolt industry is to remain at 18 for cutters, bolt headers (hot), strippers, brazers, cold headers and feeders. The demand for nuts and bolts does not allow of a reduction of the personnel in the industry. In the motor tyre industry, tyre builders (rubberers) making giant tyres—large numbers of which are required for Service vehicles—are to continue reserved at 25, but those making other tyres will, on October 1, be de-reserved up to 30. Tyre strippers, treaders, repairers (india-rubber) and moulders (india-rubber) will remain reserved at 25.

THE ADMIRALTY EXPERIMENT WORKS, TORQUAY.*

By R. W. L. GAWN, R.C.N.C.

(*Continued from page* 160.)

PROBABLY the most outstanding achievement of the Torquay Tank was to indicate the large extent to which the breadth and midship section of a ship could be increased in relation to length, draught, and displacement, not only without sacrifice of speed, but actually with improvement. Prior to these experiments it was generally held that small beam in relation to length and displacement was the most satisfactory method of obtaining a good steam performance, but such a doctrine was an obvious menace to the safety of ships and might well have been responsible for some unfortunate disasters at sea. The discussions in the *Transactions*, *e.g.*, the 1871 and 1878 volumes, afford illuminating evidence in this respect. Consideration of some of the contemporary examples of the improvements effected by increase in beam is not without interest. At the time of the design of the Medway class of river gunboat, the Admiralty planned for a breadth of 26 ft., similar to that of the H.M.S. Snake, a former gunboat of much greater length. Froude tested some models in 1875 which showed that substantial advantage would be obtained by increasing the breadth to 34 ft., an anticipation well confirmed by the trials. In an appendix to a report on H.M.S. Inflexible, dated 1878, R. E. Froude gave the result of an experiment by his father on a model of H.M.S. Ajax, compared with that of another design of the same displacement as in Table I, on page 198. Thus, the ship of much greater beam and midship section area not only has a smaller resistance, but that resistance increases at a smaller rate with increase of speed. Another important case was that of H.M.S. Iris, in which similar improvements were effected and there were numerous others. Such striking instances of improvement due to larger beam and finer water-lines are recognised nowadays as due to the reduction in prismatic coefficient, that for the narrower-beam designs being excessive at wave-making speeds.

In the first epoch-making years at Torquay, the records show that different forms were compared primarily by their E.H.P. curves and sheer draughts, together with the Admiralty coefficients. The resistance of a model was plotted in pounds to a base of speed in feet per minute, and the skin-friction resistance correction was superposed, together with the ship results to the appropriate scale. The first systematic record was dated March 9, 1874, and comprised a number of models, many of which were tried with modifications and at different displacements, and some stern first as well as bow first. Results included curves of resistance for models and 3,500-ton ships, curves of water-lines, sinkage trim, and wave profiles. The models included Great Swan, Great Raven, Greyhound, Fury and Devastation, among others. Gradually the constant system was evolved in stages, together with the elements of form, defined by curves of areas, water-line and midship section. Although R. E. Froude did not publish his paper on the constant-system until 1888 and the elements of form diagram until 1892, the genesis dates from an earlier period. Records show that the first curve of areas comparison was introduced in a report to the Director of Naval Construction dated June 22, 1883, and resistance and dimension constants were being freely used, although in a modified form compared with those we now know. This admirable system of non-dimensional coefficients propounded by R. E. Froude was a direct result of the work at the Torquay Tank, although its full application was not evolved until the tank was transferred to Haslar. Its importance cannot be overstated, for by means of the coefficients the labour of evaluating the E.H.P. is greatly facilitated, and results in different systems of units in different countries are readily compared because the coefficients are non-dimensional. Above all, the form of the resistance constant curve itself, apart from its ordinate value, gives decisive evidence as to the qualities of the form requiring modification. The method of non-dimensional presentation of results is now common in many spheres of technical activity, but Froude's system was well in advance of the times and very comprehensive. In pursuance of the same idea, a few years later, Froude presented the results of experiments on planes and blades of different shapes and sizes and of different speeds in the form of what are now known as the lift and drag coefficients, thus anticipating the use of the system in aerodynamics by several years.

It is a reasonable speculation that one of the first fruits of the division of a form into its elements directed attention to the remarkably good performance of certain cruisers being tested in the Torquay Tank in the early 1880's, culminating in H.M.S. Vulcan. The

* Paper presented to the Institution of Naval Architects. Abridged.

first model to be tried when the experiment tank at Haslar was opened in 1887 on transfer from Torquay was designated model H A. This form was of outstanding performance, and was based on Torquay experience. The original model was used by R. E. Froude as the parent form for those methodical series tests which were reported to the Admiralty in 1888 and published in the *Trans. I.N.A.* in 1904. Shape of sections was also investigated at Torquay, and the well-known conclusion as to the advantage of U sections forward and V sections aft is still of wide application. Mention should also be made of the resistance advantage of the ram bow (which is another form of the bulbous bow), the early shapes for torpedoes, and the early form of torpedo boats.

Special mention should be made of the "Polysphenic Ship," *i.e.*, a wedge form intended to rid itself of resistance by lifting itself out of the water. William Froude has been criticised for an alleged failure to appreciate the reputed advantages of this idea, brought forward by the Rev. C. M. Ramus. The model was among the first tested at Torquay in 1872, and while it is frequently regarded as a forerunner of the wonderful modern high-speed planing forms, it is at least doubtful whether the Ramus form is truly entitled to this distinction. This model, over which much contemporary controversy was aroused, is shown in Fig. 15, on this page. A resistance curve is also shown in Fig. 16, in comparison with a modern type. It is seen that the performance of the Ramus design is markedly inferior, and it seems improbable that, even with the help of the modern internal-combustion engine, it could be made satisfactory. The Pictet form, tested in 1884, is a closer approach to modern standards both as regards performance and design. This form was evolved as a result of tests by the inventor on Lake Geneva in 1881. It differed from the Ramus in that it consisted of a single wedge instead of two, and the profile was a hollow parabola instead of an inclined plane. The stern was flat and square instead of rounded, and the design was proposed for a torpedo boat instead of a large ship.

William Froude showed his characteristic appreciation of detail in the Ramus investigation by allowing for the probable effect of air resistance. He also gave in his report a full account of what is now known as the porpoising action of planing forms in a swell. An abstract from his summary is of particular interest: "But though, in a practical point of view, it is thus manifestly impossible to realise valuable results by adopting the principle advocated by Mr. Ramus, much theoretical interest certainly attaches to it, and I must admit that it had seemed to me certain that at *some* assignable speed the skimming action would become so perfect as to obliterate, or virtually obliterate, water resistance."

He then showed, by reasoning, that no matter how small the angle of surface, "the idea of obliterating resistance at extreme speeds is altogether illusory." In order to reduce stern trim, he proposed three skimming floats as in Fig. 17, herewith, but the results contradicted the hope of "reduced resistance at high speeds." Sixty-seven years later, Froude's idea of three floats was again put to the test in the third and latest Admiralty experiment tank, in connection with the design of the record speed craft Bluebird II. The first attempts to embody the idea were extremely discouraging both as regards speed and safety, but eventually a form was evolved, the results of which fully confirmed the Torquay tests that the hope of reduced resistance at high speed was illusory. Nevertheless, the form was the most satisfactory for the high speeds in view and an improvement on that of Bluebird I, tested at Haslar three years previously. Thanks to the craftsmanship of the builders and the intrepid courage and skill of Sir Malcolm Campbell, K.B.E., Bluebird II, with the three-float arrangement, obtained a world record speed of 141·38 miles an hour in August, 1939. Among other types of forms tested in those decisive 1870's were the circular ironclads for the Russian Navy. This type has not been reproduced, so far as is known, but Froude received an appreciation from the Russian Government for his services in these tests, and there was until recently at Haslar a permanent reminder of this in a circular slide rule presented by that Government to the Establishment. The instrument has been presented to the Science Museum.

Apart from progress reports during building, the first report on results was forwarded to the Admiralty on August 14, 1871, as an interim report on the surface-friction experiments. Following these, model experiments were put in hand and we find a report dated December 13, 1872, addressed to Dr. Woolley and the Chief Naval Architect, giving the line of inquiry which Froude had shaped out as best adapted to determine excellence of form. Experiments on modifications of the Greyhound model had shown certain directions in which improvement could be obtained. When the bow and stern of the Greyhound model were altered to those of Warrior, the displacement being reduced from 1,161 tons to 1,067 tons, it was found that the resistance was increased by 8¼ per cent. at 8 knots and reduced by 16 per cent. at 12 knots. When the side of the Greyhound was filled out by an easy curve to give additional beam amidships, thereby increasing displacement from 1,161 tons to 1,238 tons, the resistance was very slightly increased at speeds below 12 knots, but above 12 knots was slightly reduced. Further, two models of yacht form, similar to the Swan and Raven, respectively, had about ½ knot more speed than the Greyhound or its modifications for the same or even greater displacement. Froude accordingly proposed to select a typical form and try the effect of enlarging the midship section for the same displacement and beam, variation of length and beam for the same displacement, and then, in later tests, the position of extreme beam and the modification of bow and stern lines.

The chance to put this programme partly into effect was afforded as a result of tests on the English corvette Encounter (length, b.p., 220 ft.; extreme breadth, 37 ft.; mean draught, 15 ft. 9 in.; displacement, 1,890 tons) and the French ship Infernet (length, b.p., 257 ft. 10 in.; extreme breadth, 35 ft. 11 in.;

THE ADMIRALTY EXPERIMENT WORKS, TORQUAY.

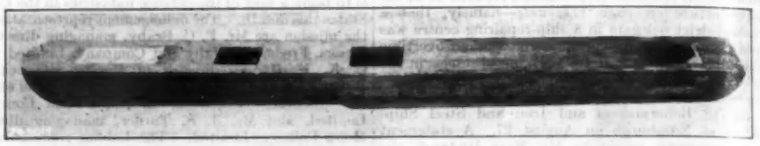
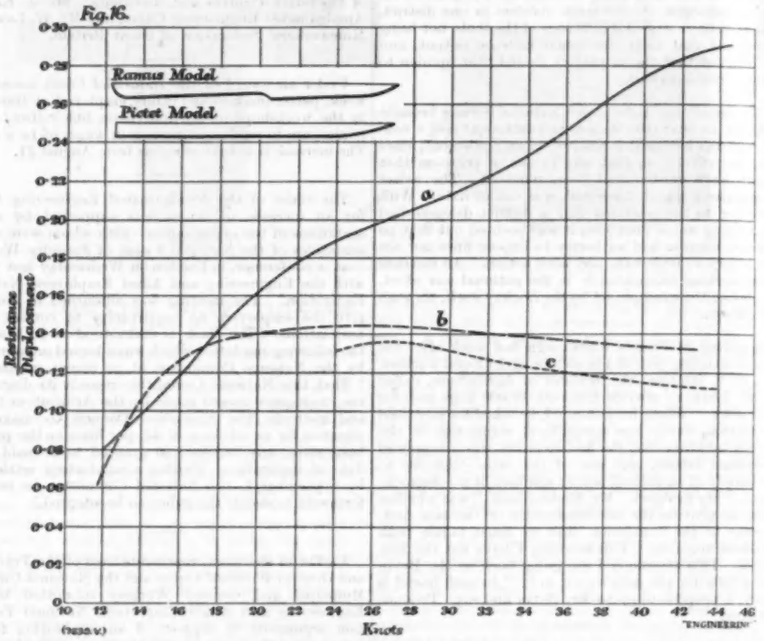


FIG. 15. RAMUS MODEL.

Fig.16.



a Resistance curve deduced from experiments on a model of design of the Rev. C. M. Ramus, M.A., 10·3 ft. length, at Torquay, reported to Admiralty, September 4, 1872.

b Resistance curve deduced from experiments on a model of design of M. Raoul Pictet, reported to Admiralty, 1884.

c Resistance curve deduced from experiments on a 9 ft. model at Haslar, reported to Admiralty, 1936.

Fig.17.

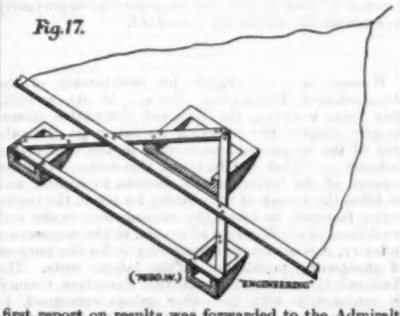


Fig.18.

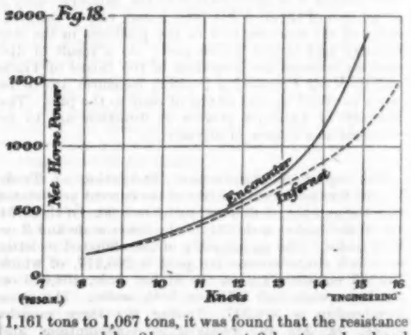


TABLE I.—EFFECT OF BEAM ON RESISTANCE.

Name of Ship.	Length, Ft.	Beam, Ft.	Mean Draught, Ft.	Displacement, Tons.	Resistance in Tons at—		
					12 Knots.	13 Knots.	14 Knots.
Inflexible	320	75	24	11,090	21·0	26·6	35·2
Enlarged Ajax	320	75·4	26	12,240	22·2	27·8	38·1
Imaginary ship	320	102·1	26	12,260	21·8	26·4	32·1

THE ADMIRALTY EXPERIMENT WORKS, TORQUAY.

Fig. 19.

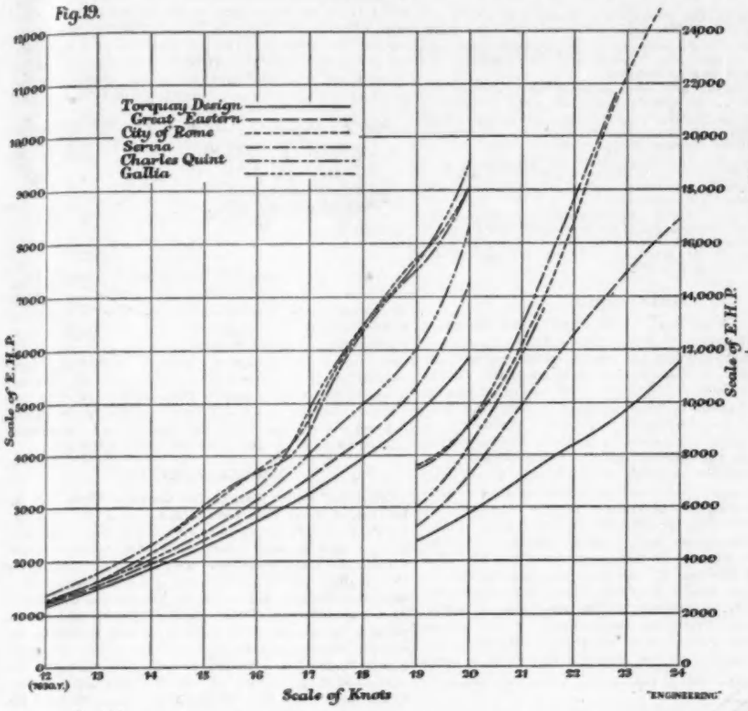


Fig. 20.

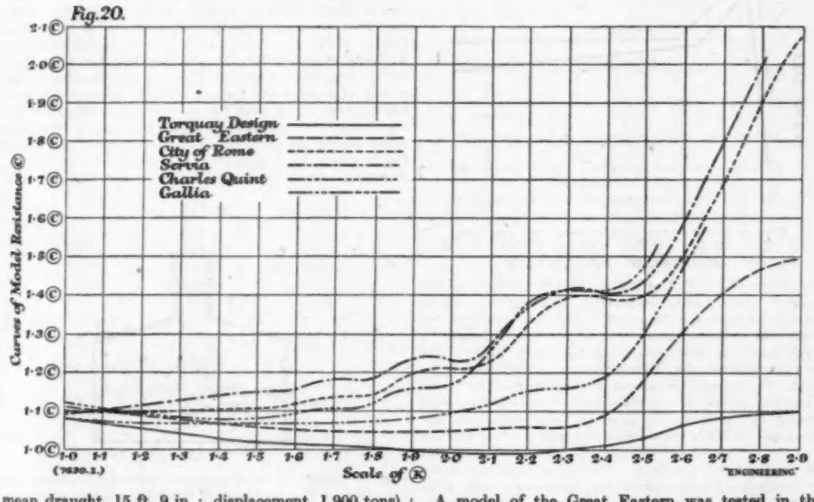


Fig. 21. (a)

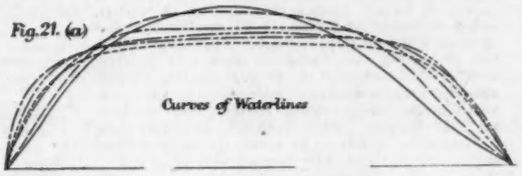
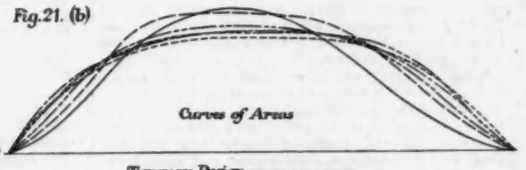
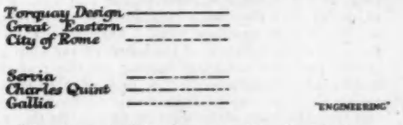


Fig. 21. (b)





mean draught, 15 ft. 9 in.; displacement, 1,900 tons). A report on these designs, dated May 17, 1873, is of historical interest because it included the first E.H.P. curves, reproduced in Fig. 18, on this page. The French ship had a marked advantage, which was recognised as due to her much greater length. It was considered that better performance could be obtained on a reduced length by expanding the midship section. Two other points in this report are noteworthy. First, Froude recommended that E.H.P. be taken as 38 per cent. of indicated horse-power, based on Greyhound trials, although he did not define the term "propulsive coefficient." Secondly, first mention is made of an apparatus being constructed to test screw propellers behind the model, and it was requested that the dimensions of the propellers for Encounter should be forwarded. In a subsequent report, dated June 2 of the same year, some of the modifications referred to above were tested, and a short Infernet was found to be much better than Encounter, due to her lower prismatic coefficient. This report was further noteworthy in that the prismatic coefficient was evaluated without then being defined as such. The report noted that there might be an objection to the finer ends, in that loss of buoyancy might react on steadiness in a head sea, but speculated whether this objection could be met by an appropriate disposition of weight.

A model of the Great Eastern was tested in the Torquay Tank for information in 1885, nearly 30 years after she was built. E.H.P. curves are shown in Figs. 19 and 20, herewith, together with those of other models of merchant ships tried at Torquay. The main particulars of these ships, brought to a common displacement of 10,000 tons, are shown in Table II, below. Curves of water-lines and areas are shown in Figs. 21(*a*) and 21(*b*) also on this page, and include those of a Torquay model made to compare with the others. These

TABLE II.—*Comparative Dimensions of Ships, at 10,000 tons Displacement.*

Ship.	Length, Ft.	Beam, Ft.	Mean Draught, Ft.
Great Eastern ..	486	59	21·5
Torquay Design ..	469	61	24·3
City of Rome ..	485	47	22·8
Servia	467	48	23·5
Gallia	469	49	23·4
Charles Quint ..	463	51	24·3

curves are interesting not only as a comparison, but also as a record of the standard of resistance of this old and famous ship. The superiority of the Torquay model is very marked, particularly bearing in mind that it is one of the shortest of the forms considered. The beam and draught are also greatest, this affording another instance of the advantageous effect of large beam. The Great Eastern is the design of next greatest beam, and it is certainly a remarkable tribute to her designers and builders that the form is so decidedly superior to that of the other ships considered.

The famous warship H.M.S. Warrior was laid down in 1859, and a model was tested at Torquay in 1884, both for resistance and as regards screw performance with different sizes and location of propellers, and as a twin- and single-screw ship. The investigation was noteworthy on three accounts. Firstly, on page 25 of the volume of the *Trans. I.N.A.* for 1865 there is an estimate by Rankine giving the resistance of the Warrior at 14·35 knots as 76,177 lb. On this page of the volume in the author's office there is an annotation in pencil by R. E. Froude that the resistance deduced from the model experiments was 49,000 lb., indicating an over-estimate by Rankine of 55 per cent. This is another important indication of the value of the experiments at the Torquay Tank, since it can be taken that Rankine's estimate was as close as was then possible. Some of the results of the screw experiments are interesting, since they constitute the first investigation into the details of propeller size and arrangement. It was found that a small single screw had a slight advantage in hull efficiency as compared with a large screw, but the enhanced screw efficiency of the latter more than turned the scale. The efficiency of twin screws was superior to that of the single screw, but not sufficient to neutralise the greater hull efficiency of the latter. Thus it was confirmed that twin screws in this ship had no efficiency advantage to set against the loss on the score of greater shaft resistance, which exceeded the rudder and rudder-post resistance in the single-screw arrangement. The third interesting point relates to the propulsive coefficient deduced from measured-mile trials, as in Table III, below. R. E. Froude could not suggest any assignable cause for the large differences in propulsive efficiency.

TABLE III.—*Propulsive Coefficients of H.M.SS. Warrior and Black Prince.*

Date of Trial.	Speed (Knots).	I.H.P.	E.H.P.	E.H.P. I.H.P.
Warrior.				
Oct., 1861 ..	14·36	5,469	2,251	0·412
April, 1868 ..	14·08	5,267	2,154	0·409
May, 1874 ..	14·16	4,811	2,179	0·453
Black Prince.				
Nov., 1861 ..	14·21	5,070	2,028	0·400
Sept., 1862 ..	13·60	5,772	1,956	0·338
May, 1863 ..	13·50	5,096	1,887	0·370
July, 1868 ..	14·04	5,571	2,086	0·374
Sept., 1875 ..	23·50	5,470	1,872	0·342

The earlier forms of torpedo boats tested in the Torquay Tank, while of good contemporary standard, were not of special merit compared with modern forms, as the flat stern had not been introduced and the appropriate prismatic coefficient and other features had not been fully investigated. Some of the forms had a bulbous deadwood aft to take the screw propeller and shafting, an arrangement which proved prejudicial to hull resistance and propulsive efficiency, and was subsequently given up. Great length in relation to displacement was soon recognised as a very important

factor in determining performance, and one of the Torquay forms is distinguished by having a length constant in the Haslar notation equal to 12·4, the greatest of any form tested. An interesting feature of these early torpedo boats is that their length of 81 ft. and displacement of 33 tons is comparable with that of modern motor torpedo boats. Curiously enough, too, the models were frequently made to a standard length of 9 ft., which is the present standard adopted independently for models of modern fast torpedo boats tested in the larger tank at Haslar. Whereas, however, the Torquay models could only be tested up to corresponding speeds of 20 knots, the modern boats are tested at speeds very considerably in excess of this and at heavier loadings.

A very important routine test initiated by William Froude was the automatic record of what is colloquially termed the "fall of ends." Two drums were mounted about 10 ft. apart on the resistance-dynamometer carriage, vertically above the middle line of the model, and on these the vertical movement up or down was recorded of two points, one towards the bow and one towards the stern of the model, at a series of speeds. These records were taken automatically at the same time as the resistance experiments, and were found so useful that they have continued as an important feature of each approved form. They serve not only to indicate the change of freeboard of the ship with speed, but give evidence bearing on the respective merits of alternative designs and of the features responsible for any differences in performance. In addition, the trace of the wave profile against the ship's side at certain speeds is carefully recorded on a background of uniformly spaced vertical and horizontal lines on the topsides of the model. These records are useful for assessing vertical limits of side armour, position of hawsepipe, and openings and fittings on the ship's side, and also give a good indication of the dryness of the ship and appropriate freeboard. Seaworthiness was of special importance in the design of the low-freeboard ships of Froude's day. A report on the Comet class, in 1877, shows that thirteen models were tested, each to a scale of one-twelfth full size, the first being a model of the Snake, already built to dimensions of 85 ft. by 26 ft. 1½ in. by 6 ft. 3 in. (= 254 tons) and the others being of same length and draught, but 2 tons heavier and nearly 4 ft. more beam. The resistance of the final form at the service speed of 9 knots was 1·28 tons, compared with 1·98 tons for the Snake and 1·5 tons for the first Admiralty design to the larger beam, an obviously remarkable improvement corresponding to ¾ knot gain in speed. An important requirement was that the ship could be safely towed at higher speeds by another vessel. The following brief abstract of the conclusions is significant of the improvement achieved in this connection. "The 'tip' of the ships of the very U-bowed designs DS_2 and DV would be serious in amount, and would obviously be fatal to any attempt to tow them at high speeds. The 'tip' of the ships of the flaring bowed design DU_2 and the spoon bowed designs EB and EB_2 would be considerably less than that of the others, and would be in the case of the two latter obviously (and in the case of the former probably) not such as to prevent their being towed even at 15 knots in smooth water."

In these early experiments a good deal of attention appears to have been devoted to the form of the bow. An interesting test in 1873 was on a model of H.M.S. Fury, a battleship 320 ft. long by 72·56 ft. beam and 26 ft. mean draught, and 10,688 tons displacement at fighting draught. The ship had the low freeboard forward of 4 ft. 6 in., and a bow addition was fitted with the object of keeping water off the deck forward when steaming, and so improve performance. In this respect the bow addition was unsuccessful, the performance being almost unaffected, and there was a large depression of the bow equal to about half the freeboard at about 14 knots. The bow was then raised by an amount sufficient to keep the deck dry, following a similar successful modification on a previous model, and as a result the E.H.P. was reduced by about 12 per cent. at 14 knots. The model was also fitted with flat boards at the bow, variously disposed to suppress the bow wave, with benefit to the performance, but it would appear that, as with the raised bow, the improvement was a direct result of preventing the wave from washing over the deck forward. When the boards were fitted, the trim was changed from 0·35 deg. by the bow to 0·34 deg. by the stern, and the sinkage was only about one-third of its former value.

(To be continued.)

MAXIMUM PRICES FOR COTTON WASTE.—The Control of the Cotton Industry (No. 24) Order (S.R. & O. 1941, No. 1187, price 2d.), lays down maximum prices for cotton waste. The Order applies to all the commoner types and descriptions of waste. It does not apply to existing contracts or to sales, outside the United Kingdom, of waste not intended to be imported.

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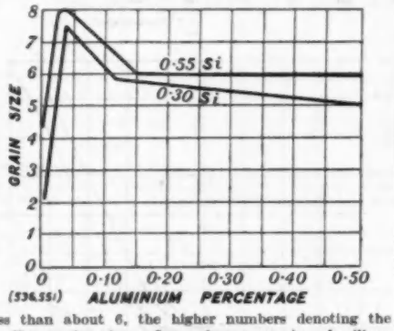
METALLURGY.

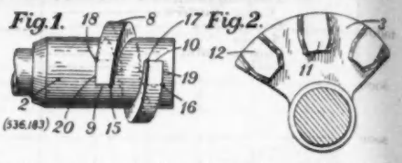
536,551. Alloy Steel. The Mond Nickel Company, Limited, of London. (6 *Figs.*) May 1, 1939.—In general, a fine-grained steel will not harden or will harden only non-uniformly and shallowly when subjected to the usual hardening heat treatment. The use of aluminium in the deoxidation of the steel directly affects the grain size, and if deep hardening is required, the maximum amount of aluminium added to the ladle is 1 lb. per ton of steel. As the silicon content (which is present in nearly all steels in amounts varying from 0·10 per cent. to 0·30 per cent.) increases, the amount of aluminium is reduced, although a fine grain cannot be obtained even by high silicon in the absence of aluminium. Either silicon or aluminium used alone in sufficient quantity will produce a coarse-grained steel, but it has now been found that the use of the two elements together in amounts that would ordinarily cause grain-coarsening if used singly, surprisingly results invariably in a fine-grained steel. From the curves shown it will be seen that if the silicon content is 0·55 per cent. the grain size-number measured on the McQuaid-Ehn scale is never



less than about 6, the higher numbers denoting the smaller grain sizes. Increasing amounts of silicon greatly increase the range of aluminium available for grain size control, particularly at the lower aluminium levels where accurate control is most difficult and also greatly increase the deep-hardening properties of the steel. The aluminium and silicon contents must be varied according to the base composition of the steel and the size of the section. In general, the best results are obtained when the aluminium content is from 0·1 per cent. to 0·2 per cent. and the silicon content from 0·4 per cent. to 0·6 per cent. The advantages in respect of hardening and mechanical properties are most marked in the larger sections and in those steels which normally have relatively low hardness. The effects are particularly good in steels containing 0·4 per cent. to 1·25 per cent. nickel, 0·4 per cent. to 0·7 per cent. chromium, 0·5 per cent. to 1·2 per cent. manganese, and 0·35 per cent. to 0·65 per cent. carbon, with aluminium and silicon in the amounts specified above. These alloys can be used with advantage in the manufacture of machine parts and tools such as shafts, gears, dies, headers, etc. (*Accepted May* 19, 1941.)

MOTOR VEHICLES.

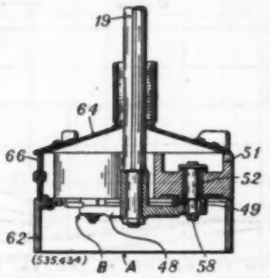
536,183. Steering Gear. R. Bishop, of Golders Green, and R. H. Johnston, of Westminster. (3 *Figs.*) November 3, 1939.—In this invention the steering column carries a cam 2 (Fig. 1), and the follower 3 (Fig. 2) is secured on a rocker-shaft, the follower and cam being enclosed in a casing. The cam 2 consists of a worm 8 which has less than a single turn of complete land and yet has sufficient worm groove between the adjacent ends of the thread to ensure the transfer of the drive from one tooth 11 of the follower to the next tooth 12. The complete land is less than 360 deg., but each flank of the thread extends over approximately 360 deg. from a starting point located one at each side of the centre of length of the worm and at an angle to each other which causes the starting ends of the flanks to overlap. Thus the starting point 15 of the flank which finishes at 16 is spaced approximately 20 deg. around the axis of the worm from the starting point 17 of the other flank which finishes at 18. Consequently the starting ends 15 and 17 of the flanks overlap for this amount. The finishing end of a flank, say 16, terminates 20 deg. short of the starting point of the other flank, 17. The portions of the worm from the point 16 to the end 10 and from the point 18 to the end 9



are formed with outer faces 19 and 20 respectively lying in planes at right-angles to the axis of the worm. With this formation of the worm the transfer of the drive from one tooth of the follower to the next only involves the simultaneous engagement of three tooth-sides with flanks of the worm thread. After a tooth has become engaged, only two tooth sides are in contact with the flanks of the worm thread. The cam is simpler to produce, is shorter in axial length and the teeth on the follower are stronger since more metal can be left inside of their arcs of contact. (*Accepted May* 6, 1941.)

MISCELLANEOUS.

535,434. Roller Packer for Concrete Pipes. J. H. La Due, of Sioux City, Iowa, U.S.A. (5 *Figs.*) November 21, 1939.—The packer head A has a spider mounting B with a hub through which passes the reduced lower end of the main shaft 19. The spider is clamped on this shaft. The arms 48 of the spider terminate in elongated bearings 49, which support the packing rollers 51 on spindles 52. The spindles 52 can be adjusted radially by means of lock nuts 58 and adjusting set screws. Plates are bolted between and below the rollers 51 and their edges adjacent the rollers are shaped to the curvature of the rollers. A trowelling skirt 62 is bolted to the plates, its external diameter being that of the bore of the pipe to be formed, and the rollers are set so that they are flush with the perimeter of the trowelling skirt. Above the spider B is a sheet-metal cone 64, which is of less external diameter than the trowelling skirt. Adjustable plates 66 close the spaces between the rollers 51 around the packer head to prevent concrete which drops down over the cone from getting into the interior of the head. The plates are set in from the perimeter of the skirt to allow for recesses into which the concrete may drop to be packed by the rollers. Adjustable blades and plates on the upper surface of the



cone control the supply and distribution of concrete to the rollers. The operation of the roller packer head is as follows:—The pipe mould is placed on a turntable and a hopper is lowered into position above the mould. The packer head closes the bottom of the mould. The shaft 19 is then coupled to the driving shaft, and concrete is supplied through the hopper. The shaft and packer head are then slowly raised by a hydraulic-ram mechanism. As the packer head rotates and slowly moves upward the rollers 51 thoroughly pack the concrete into the mould to form the pipe. The concrete passes down over the upper cone of the packer head and into the recesses between the rollers 51. All of the concrete passing into these recesses must be packed into the pipe, and the effectiveness of the packing depends upon the amount of concrete admitted to the recesses by the plates on the surface of the cone. When the pipe has been packed and the roller packer head has been raised to its highest position, the hopper is raised and the turntable rotated to remove the finished pipe from the zone of operation of the packer head and to bring a new mould into position for another cycle of operations. It has been found that the roller packer head can be made to put more pressure on the concrete than the trowelling-type packer head, and hence with the roller packer head it is possible to use relatively more coarse aggregate and relatively less cement than would be possible with the trowelling-type packer head. (*Accepted April* 9, 1941.)